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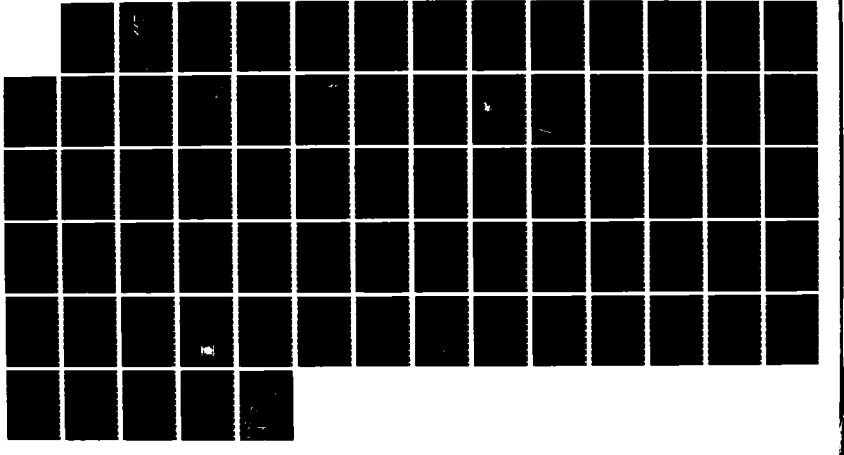

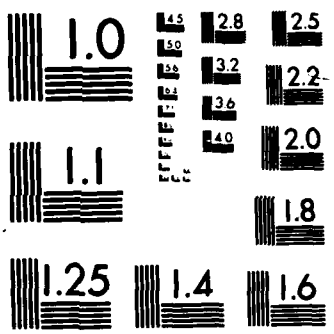
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October 1986
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Behavioral Sciences

Educational Psychology in Spain ..... Richard E. Snow 331

Two conferences, one in Madrid, the other in Seville, in June 1986 are summarized. Spanish educational psychology seems to be starting well. It has embraced the relevant most modern theories and methods of English, French, and Russian scientific literature. It includes central recognition of the importance of ecology, and it is clearly constructive rather than behavioristic in its view of human development.

Biological Sciences

Life Sciences Conference, "From Enzymology to Cellular Biology" ..... Claire E. Zomzely-Neurath 333

The topics of this conference ranged from biochemical and enzymological studies and metabolic regulation to molecular biological approaches including gene regulation and expression, enzyme engineering, and biotechnology. The major impact of molecular biological techniques was evident from the presentations.

Computer Sciences

Early Steps Toward an Optical Computer ..... J.F. Blackburn 338

Heriot-Watt University, Edinburgh, UK, has made progress toward an optical computer. Their achievement in discovering very large nonlinearity in the response of indium antimonide to light was the key to their succeeding work on the optical transistor and the construction of currents which demonstrate various portions of an optical computer in primitive form.

Mechanics

Symposium on Finite Element Methods and Flow Problems ..... Eugene F. Brown 342

This symposium, held in June in Antibes, France, served to demonstrate the impact finite element methods are having on the fluid dynamics community. This article reports principally on presentations in the areas of turbulent flows, compressible flows, and computational techniques.

Ocean Sciences

18th International Liege Colloquium ..... Jerome Williams 347

Papers given at the Liege colloquium covered large-scale, shallow-water, small-scale, and mesoscale models and modeling techniques. Although very little really new material was introduced, the strengths and weaknesses of various models were made apparent.

Physics

An Interesting Topical Conference on Integrated Optics ..... Paul Roman 352

Presentations are reviewed in areas of III-V compound based integrated systems, materials for integrated optics waveguides, devices for modulation and switching, and nonreciprocal and nonlinear integrated optics. These talks were given at the Third International Symposium on Optical and Optoelectronic Applied Sciences and Engineering, and formed the core of the constituent conference entitled Integrated Optical Circuit Engineering. The meetings took place at Innsbruck, Austria.

Theoretical Work on Laser-Induced Scattering, Atomic Physics, and Wiggler Design at Innsbruck ..... Paul Roman 355

The research group for Physics of Electromagnetic Interactions, Institute of Theoretical Physics, University of Innsbruck, Austria, is small and has limited resources, but has excellent scientists working on scattering in strong external fields, Rydberg systems (thresholds and wavepackets), quantum jumps, and the calculation of realistic, complicated, magnetic wiggler fields.

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Behavioral Sciences

EDUCATIONAL PSYCHOLOGY IN SPAIN

by Richard E. Snow. Dr. Snow is Professor Education and Psychology at Stanford University. He was the Liaison Scientist for Psychology in Europe and the Middle East for the Office of Naval Research's London Branch Office from 1983-1985.

The growth of scientific psychology in Spain was stunted first by the strictures imposed by its origins in a rigid philosophy and then by the attitudes of the Franco Government. Although perhaps not actively suppressed as a pseudoscience, psychology was certainly not promoted in Franco's Spain.

In the last decade or so, however, Spanish psychology has grown rapidly and begun to bear fruit. In numbers, Spain now has roughly about as many psychologists per million population as Scandinavia and the Benelux countries, and the growth rate exceeds that of Britain, France, West Germany, and the US. A significant fraction of this new crop aims to do science, especially as it can inform and help improve critical societal functions such as education. Many young and energetic Spanish psychologists are now busy reading and translating research from other countries, looking for the most promising directions, and mounting research projects toward them. Early attention focused on French psychology. Of particular interest more recently, however, are the Swiss-French theories of Piaget and the Neo-Piagetians, Soviet research based on the theories of Luria and Vygotsky, and British and US child-social, personality, and cognitive psychology. The Spanish are increasingly reaching out to both east and west for research guidance, as the lists of invited speakers in recent years clearly demonstrates. There is now a US-Spanish joint committee for cultural and educational cooperation that is funding and helping to promote scientific exchange visits and projects. (Executive offices are at Paseo Del Prado, 28-5a Planta, 28014 Madrid, Spain.)

New Directions in Spanish Educational Psychology

Two conferences, held in Madrid and Seville in June 1986, exemplify some of the new directions now being taken by Spanish research in the area of overlap between psychology and education. About 1000 Spaniards, representing all regions of the country, participated in one or both of these conferences. Invited speakers came from the US, Britain, Canada, the Netherlands, and Flemish Belgium. Several Soviet speakers were invited but were unable to attend. The larger of the two conferences, "II Jornadas Internacionales de Psicologiay Educación: Cultura, Educación y Desarollo Humano," was organized by Dr. Amelia Alvarez and Professor Pablo Del Rio of the psychology faculty at Universidad Complusense in Madrid. Both are also editors of the Journal *Infancia y Aprendizaje*, covering psychology and education in human development. The other conference, "I Congresso Internacional Pensamientos de los Profesores y Toma de Decisiones," was organized by Professor Luis Miguel Villar of the education faculty at Universidad de Sevilla.

Though the two conferences overlapped somewhat in content, it was the contrast between them that was most striking. The Seville conference focused on teachers, the relation of teacher decisions and actions in teaching processes, and the implications of this research for teacher training. An emerging, cognitive psychology of teaching seems clearly to be taking shape. But rather little was said about students' learning, or about particular subject-matter. At the Madrid conference, on the other hand, the emphasis was primarily on students and particular subjects of learning. The conferees discussed the full age range--from infants and young children through middle-aged adults--and a wide variety of research topics and approaches, from social and ecological through developmental to cognitive and linguistic psychology. But rather little was said directly about teachers and teaching. This unfortunate bifurcation between research on teaching and on learning is clearly visible in the US, and it is now seen also in Spain.

The division is understandable. Research on teaching is the newer field, seeking to identify and establish itself as a separate, worthwhile focus in its own right. It is true that teachers and teaching processes have been relatively neglected across decades of research on student learning in instructional psychology. Teachers are, after all, only one part of the spectrum of important influences on student learning. On the other hand, teachers can have profound effects, both positive and negative, on the cognitive and motivational development of students. Teachers are not only a medium of instruction; they are powerful models of human cognition, emotion, and social competence and are perhaps second only to family members in their

human modeling influences on the lives of students. This influence ought not to be left out of considerations in research on student learning. For the same reason, the psychology of student learning ought not to be left out of research on teaching and teacher training. Whatever else it does, teacher training ought to include extensive and intensive subject-matter-based interaction between teachers and students as its basic training medium.

The Seville Conference

In the Seville conference, teacher cognition was examined in several new ways. Whereas earlier research on teaching was usually limited to the identification of teaching skills and classroom behavior that might promote learning, today's research has expanded to include teacher planning and decision-making prior to as well as during classroom action. Some research has been analyzing cognitive schemata or scripts that seem to be used by teachers to organize their behavior. More effective and less effective teaching routines can thus be identified. Another important thrust concerns the teacher's subject-matter knowledge. The organization of teacher's knowledge will likely have major effects on teacher decisions about what to teach and how to teach it. Teachers seem to have an image of what they plan to teach that combines knowledge of subject matter with a set of expectations and routines, organized into a temporal flow much like a script for a movie. This script will then be followed more or less automatically unless something goes wrong. So far, the research is descriptive, but by locating particular teaching skills in an organized temporal flow, it holds the promise of showing when and how particular skills can be exercised. The theoretical perspective here is cognitive, however, where action is regarded as thinking-while-doing, rather than behavioristic, which would emphasize merely the performance of skills. Another important side of this research makes comparisons between teachers regarded by some criterion as experts with teachers considered to be novices. The evidence from these comparisons so far suggests that expert teachers have more well-formed schemata, particularly about the students to be taught. They are more able to make appropriate inferences about classroom events and seem to have a higher-order system for classifying such events. Novice teachers, by contrast, react to the surface characteristics of individual student performance and may thus use signals in teaching that are confusing to students. They make simplistic interpretations of classroom situations. Teacher trainees, furthermore, may emulate expert behavior but fail to appreciate the reasons behind expert teaching or classroom management strategies. It seems clear also that trainees do not always learn from collaboration with experts, even when expert strategies are made explicit.

Although the main interest of most Seville participants was to obtain ideas for the improvement of teacher training, it seems clear that research has not yet progressed far enough to reach solid recommendations. Three main lines of suggestions for teacher training coming from the conference are reasonable but as yet vague on details. These are: (1) to concentrate on strategic organization of the temporal flow of teaching--on action plans rather than particular skills; (2) to emphasize intimate knowledge of subject-matter; and (3) to use this knowledge, along with sensitivity to the likely forms of student misconceptions, in diagnostic teaching-learning interaction. It remains to be seen whether Spanish research on teaching--and US research for that matter--can make significant progress toward improved teacher training along these lines.

The Madrid Conference

The Madrid conference presented some themes that carry suggestions for research on teaching similar to those noted above. Diagnostic teaching geared to student misconceptions in mathematics and science, for example, was one Madrid topic related closely to Seville interests. Another was curriculum design as an influence on teaching and teacher training. For the most part, however, implications for teaching based on the Madrid presentations would be generalizations from studies of student cognitive or social functioning, of parental teaching styles, or of the characteristics of successful "mentors"--persons other than parents who play significant roles in children's lives.

A wide variety of other topics were also addressed. A partial list of these topics includes the following:

1. The changing ecology of childhood brought about by the increases in the numbers of mothers who work outside the home, increased use of day care systems, etc.
2. The characteristics of effective preschool intervention programs, particularly with parents and children who have not previously had access to institutionalized preschool education.
3. The problems of special education for persons with various sorts of handicaps.

4. The role of the school psychologists in relation to others involved in students' well-being.

5. The new information technologies and communications media, and their uses and influences, particularly as they provide informal education outside the formal school but also as a tool for teachers and curriculum designers.

6. The nature of first- and second-language proficiency, the differences between oral, written, and reading language acquisition, and the problems of bilingualism.

7. The cognitive, social, and emotional development of children across the school years, including individual differences in these developments.

Summary

As in Seville, the largest proportion of Madrid participants seemed concerned primarily with reaching solutions to the important practical problems faced in professional educational life in Spain. And again, the research has not progressed to the point of satisfactory recommendations. But Spanish educational psychology seems to be off to a good start. It has embraced the most modern theories and methods of English, French, and Russian scientific literature. It includes central recognition of the importance of ecology--simple generalizations across all persons and situations are not likely to be forthcoming. And it is clearly constructivist rather than behaviorist in its view of human development. I hope, however, that it will not make the mistake of compartmentalizing its educational psychology into teacher education, curriculum design, special education, and student learning divisions.

7/18/86

Biological Sciences

LIFE SCIENCES CONFERENCE: "FROM ENZYMOLOGY TO CELLULAR BIOLOGY"

by Claire E. Zomzely-Neurath. Dr. Zomzely-Neurath is the Liaison Scientist for Biochemistry, Neurosciences, and Molecular Biology in Europe and the Middle East for the Office of Naval Research's London Branch Office. She is on leave until July 1987 from her position as Director of Research, the Queen's Medical Center, Honolulu, Hawaii, and Professor of Biochemistry, University of Hawaii School of Medicine.

Introduction

This conference, entitled "From Enzymology To Cellular Biology," was organized by J. Szulmajster and other members of the Laboratory of Enzymology of the Centre Nationale de la Recherche Scientifique (CNRS), Gif-sur-Yvette, France, to celebrate the 25th anniversary of its creation. There were 150 participants at this small, focused meeting, including invited speakers and scientists presenting posters. While the largest number of participants were from France, five other European countries were represented, as well as the UK, the US, Pakistan, and India.

The topics of the papers at this conference ranged from biochemical and enzymological studies and metabolic regulation to molecular biological approaches including gene regulation and expression, enzyme engineering, and biotechnology. The major impact of molecular biological techniques, including recombinant DNA (rDNA) methods and site-directed mutagenesis on the progress in the area of enzymology, was evident from the presentations at this conference. The importance of combining information from classical kinetic and equilibrium studies as well as x-ray crystallography with the more recent molecular biological approaches was also emphasized.

A summary of some of the many interesting topics covered at this conference is presented in the following sections. ONRL report C-6-86 contains a detailed account of the conference presentations.

Enzymology, Yesterday, Today and Tomorrow

W.N. Lipscomb (Harvard University, Cambridge, Massachussetts) discussed what he considered the important aspects of the present and future research in enzymology. An essential component in enzymology research is the determination of the three-dimensional structures of enzymes and their complexes. Lipscomb emphasized that x-ray diffraction studies do not establish mechanisms of protein folding, activity, or regulation. He stressed that it is only when the structural results are combined with those of other methods that these mechanisms can be addressed. Studies using the recent method of site-specific mutagenesis are now playing and will play even more in the future a very important role in structure/function studies. Nuclear magnetic resonance (NMR) studies, especially

on site-modified residues is becoming increasingly effective. Other spectroscopic methods are being used in addition to NMR to identify the presence of intermediates, and low-temperature studies are beginning to be used widely. However, Lipscomb pointed out that the more classical kinetic and equilibrium studies are still required. Present and future research objectives in enzymology research include: (1) the causes of protein folding, (2) the role of domain structures and structural dynamics, (3) the role of solvent, and (4) the design of new enzymes for catalysts.

Lipscomb stated that for the future of x-ray diffraction studies, he expects that the combination of area detectors, synchotron radiation, low-temperature techniques, and large computers will make structures and their complexes available at an increasing rate. Furthermore, new enzymes and other proteins are also becoming available owing to genetic engineering and the fact that sequences can be varied at will. In addition, the relatively untouched area of membrane proteins is opening up as reagents are being developed to crystalize them. Methods for obtaining large amounts of x-ray diffraction data are improving, according to Lipscomb, as well as combinations of heavy atom derivatives, anomalous scattering, and molecular (fragment) replacement. With the advent of these recent, sophisticated methods for analyzing structure/function relationships of enzymes, the solution to the question of how enzymes work will probably be resolved in the near future.

J. Hajdu (Laboratory of Molecular Biophysics, Oxford, UK) presented some of his recent innovative studies on glycogen phosphorylase, the key control enzyme of glycogen metabolism in muscle and liver. Hajdu and colleagues in Oxford are carrying out detailed x-ray crystallographic studies aimed at elucidating the stereochemical basis of the enzyme mechanism and its control. Hajdu is using fast crystallographic data collection techniques and the intense x-radiation generated on a Wiggler magnet to monitor events in three dimensions on the catalytic pathway as the substrate is converted to product. With his method, data can be recorded in 250 milliseconds. This has made possible a series of dynamic experiments in which the conversion of substrate to product can be monitored in the same crystal.

Studies of the dynamics of multienzyme reactions at the surface of plant cells were presented by J. Picard (Centre de Biochemie et de Biologie Moleculaire du CNRS, Marseille, France). Experiments on the effects of the microenvironment on plant cell wall enzyme activity has enabled Picard to propose a novel theory of the ionic control of plant cell wall extension and buildup. The basis of the theory is the existence of an electrostatic potential difference between the inside and the outside of the cell wall. Picard presented data on his studies to support his hypothesis.

J.P. Waller (Laboratoire de Biochemie, École Polytechnique, Palaiseau, France) presented some of his recent research on the structural organization of aminoacyl-transfer RNA (tRNA) synthetases in eukaryotes. All aminoacyl-tRNA synthetases (AARS) of lower eukaryotic (e.g., yeast) and mammalian origin display the ability to bind to immobilized polyanionic supports (e.g., heparin, RNA) through electrostatic interactions in conditions where the corresponding enzymes from prokaryotes do not bind. Waller suggested that the evolutionary acquisition of this binding property by all eukaryotic AARS indicates that they fulfill an important function *in vivo* unrelated to catalysis which may ensure the compartmentalization of AARS within the cytoplasm through electrostatic interactions with negatively charged components.

Unlike lower eukaryotic AARS, those of mammalian origin display the property of forming multienzyme complexes. Waller and his group, in a study of nine AARS from various sources, were able to obtain high molecular weight entities yielding a heterotypic multienzyme complex comprising each of the nine AARS and composed of eleven polypeptides. They also found that complex formation is mediated by hydrophobic interactions. Waller et al. obtained evidence of the existence, therefore, of a hydrophobic domain distinct from the catalytic domain and responsible for complex formation. Furthermore, AARS specific for Trp, His, and Thr representative of those enzymes which are not encountered as complexes do not display hydrophobic properties. Waller suggested that complex formation may contribute to the stabilization of the "loose" method of AARS electrostatically bound to cellular components at or near the site of protein synthesis by establishing connections between these enzymes through hydrophobic interaction. These studies by Waller et al. may be an important contribution to understanding the mechanisms of action of those AARS which are key enzymes in protein synthesis.

Enzyme Engineering and Biotechnology

P. Corvol (INSERM Unit 36, Vascular Pathology and Renal Endocrinology, Paris, France) reviewed the research by his group, as well as that of other laboratories, on the structure of renin and its

precursor; he then presented some of the recent work on the search for inhibitors of renin. The techniques of molecular biology have enabled the structure of the gene for human kidney renin to be elucidated, and from this data it was possible to deduce the primary structure of renin and its precursor. The site of renin catalysis is now known and three-dimensional models for renin have been proposed, thus providing a rational basis for attempts to identify its inhibitors.

Corvol et al. have recently found in studies with human renin antibodies (using primates on a normal sodium diet) that renin regulates the level of arterial pressure. These results are important as they constitute a strong incentive to discover inhibitors of the renin-angiotensinogen reaction. Renin has only one known substate--angiotensinogen. Contrary to other acid proteases which have a large variety of substrates, renin only hydrolyzes angiotensin I from angiotensinogen. Corvol and his group have also been studying the inhibitor effect of prorenin segments (natural inhibitors). They found that, indeed, renin could be inhibited by peptide fragments derived from its own prosegment. Corvol et al. have also prepared renin inhibitors homologous with pepstatin, which is a natural pepsin inhibitor originally isolated from actinomyces culture. They have synthesized peptides with up to ten thousand times more affinity for human renin than pepstatin. Intravenous administration of these peptides to the monkey lowered arterial blood pressure in a dose-dependent manner, blocked plasma renin activity, and caused a fall in the level of angiotensin II. A parallel could be drawn between the hypotensive effect of these compounds and the reduction or abolition of the enzymatic activity of renin. Thus, the studies of Corvol and his group are providing important information not only on the mechanism of action of an enzyme (renin) involved in regulation of blood pressure but also on potentially relevant knowledge for clinical use in control of high blood pressure in humans.

H. Bedquelle (MRC Laboratory of Molecular Biology, Cambridge, UK) presented a model of synthetase/tRNA interaction as deduced by protein engineering. The recognition of transfer RNAs(tRNA) by their cognate aminoacyl-tRNA synthetases is the crucial step in the translation of the genetic code resulting in the final protein product. In order to construct a structural model of the complex between tyrosyl-tRNA synthetase (Tyr Ts) from *B. Stearothermophilus* and tRNA Tyr, 40 basic residues at the surface of the Tyr Ts dimer were mutated by oligonucleotide site-directed mutagenesis. Heterodimers were created *in vitro* by recombining subunits derived from different mutants. Using these components, Bedquelle was able to find out which domains of one Tyr Ts subunit interacted with a domain of the acceptor stem of the tRNA Tyr and with the anticodon arm. These elegant studies showed the power of the new technique of protein engineering.

Protein engineering studies using site-specific mutagenesis were also reported by M.G. Courtney (Transgene, S.A., Strasbourg, France). He carried out research on the alteration of the inhibition specificity and oxidation sensitivity of α_1-antitrypsin (α-AT) by site-specific mutagenesis. This enzyme is a human serine protease inhibitor whose major physiological role is to protect the lower lung from damage mediated by the elastolytic neutrophil proteases, elastases, and cathepsin G. Hereditary deficiency of α_1-AT leads to a protein burden in the lung and is associated with a high incidence of severe pulmonary emphysema. With a view to its application in replacement therapy, Courtney and his group have produced recombinant α-AT in an *E. coli* host/vector system. Using site-specific mutagenesis techniques they have isolated a series of active center mutants of α_1-AT. These were analyzed both for their ability to inhibit various serine proteases and for their sensitivity to oxidative inactivation.

Courtney et al. have identified oxidation-resistant variants that inhibit neutraphil elastase, cathepsin G, or both. One varient of α_1-AT ($Met^{358}\rightarrow Leu$) appears to be particularly suitable for the treatment of pulmonary emphysema. Another variant of α_1-AT ($Met^{358}\rightarrow Arg$) has been found to be an efficient cofactor-independent thrombin inhibitor with potential as a clinical anticoagulant as, for example, in the treatment of various thromboembolisms or disseminated intravascular coagulation (DIC). These studies indicate that it has been possible in the case of α-AT, to perform protein engineering without access to pertinent three-dimensional structural analysis and to create new molecules with definite potential as therapeutic agents.

P. Monsan (BioEurope, Toulouse, France) discussed biotechnological applications of enzyme catalysts. These applications involve mainly hydrolytic reactions. Starch and protein hydrolysis are today's most important industrial applications of enzymes. Although about 3000 different enzyme activities have been characterized up to now, less than 30 are currently in use at the industrial level. The increase of the application of enzymes on technological levels thus involves the development of new reactions.

Monsan thinks that, more particularly, there is a lack of the use of enzymes in the field of synthesis reactions.

Monsan reviewed some recent developments in synthesis reactions catalyzed by enzymes. Three main approaches are followed to achieve synthesis reactions:

1. Use of cofactor enzymes (i.e., the coupling of an exerogenic reaction involving the stoichiometric consumption of a cofactor molecule--ATP, NADH etc.) makes possible an enderogenic synthesis reaction. The use of such reactions at a preparative scale involves the development of an efficient cofactor regeneration system. An example is the case of nicotinamide cofactors and their application to amino acid synthesis.

2. Reversion of hydrolysis equilibria--hydrolytic enzymes can also catalyze the reverse reaction. The use of appropriate thermodynamic reaction conditions or the continuous removal of reaction product thus allows a shift of the reaction equilibrium toward the direction of synthesis. For example, quite interesting developments have been obtained in the application of proteolytic enzymes to peptidic bond synthesis. Concentrated media and/or immiscible organic solvents can be used to allow a reaction equilibrium shift.

3. Use of transferase enzymes--this class of enzymes is used to catalyze the synthesis of a wide range of molecules through the transfer of a chemical moiety from a donor to an acceptor. Glycosyl transferases, for example, have been applied to oligo- and poly-saccharides synthesis (cyclodextrans, dextrans, etc.).

Metabolic Regulation

E.R. Stadtman (Laboratory of Biochemistry, National Heart, Lung, and Blood Institute, National Institutes of Health, Bethesda, Maryland) presented an extensive and excellent review of the principles of metabolic regulation. In general, the regulation of highly independent metabolic processes is achieved by controlling the concentrations and activities of key enzymes.

Stadtman used studies of glutamine synthetase (GS) from *E. coli* to illustrate fundamental mechanisms implicated in the control of many key enzyme activities, enzyme level, and enzyme turnover. GS as well as other protein components involved in its enzymatic function have been cloned, thus greatly facilitating the studies. Furthermore, it has been shown that the structural gene (glnA) for GS is controlled by several gene products. Stadtman also reported that the accumulation of altered inactive or less active forms of enzymes during aging may reflect changes in the levels of one or more of the enzymatic regulating factors or in the levels of proteases that degrade altered enzymes. This possibility is supported by studies showing that the levels of oxidized proteins in cultured human fibroblasts increase with the age of the donor and that the levels in fibroblasts of young individuals with premature aging disease (progenia, Werner's syndrome) are about the same as those in fibroblasts from a 75-year-old normal individual.

A. Sols (University of Madrid, Spain) presented some of his recent studies on the regulation of enzyme activity at physiological concentrations. He had found previously that at the macromolecular environment prevailing in animal cells some regulatory enzymes exhibit markedly different kinetic properties from the *in vitro* system. Notable among such enzymes is phosphofructokinase. In an attempt to account for the behavior of certain enzymes *in situ*, Sols and colleagues have recently developed two alternative or complementary approaches for kinetic studies of enzymes at or near their physiological concentrations. These are: (1) the "slow motion" approach in conditions that greatly lower the actual molecular activity without affecting the conformation of the enzyme and (2) the "crowding" approach based on the presence of high concentrations of polyethylene glycol. Sols et al. found that the main reason for the large differences in kinetic behavior of animal phosphofructokinases between *in situ* and *in vitro* were homologous interactions at the higher degree of aggregation that corresponds to the concentration of the enzyme prevailing *in vivo*. Sols et al. have also explored the possibility of heterologous interactions in the case of the highly multimodulated muscle phosphofructokinases. Applying their two approaches to mixtures of phosphofructokinase and metabolically neighboring enzymes, Sols et al. found kinetically significant heterologous interactions between phospho fructokinase and fructose phosphate, with activation of the former and inhibition of the latter. Sols considers that these approaches are of value for a better approximation of the accurate knowledge of enzyme regulation *in vivo*.

Studies on the microbial control of carbamoyl phosphate synthesis utilizing molecular biological techniques were presented by A. Piérard (Laboratoire de Microbiologie, Université Libre de Bruxelles, Belgium). Microorganisms exhibit considerable diversity regarding the organization and control of the biosynthesis of phosphate, a key precursor of both arginine and pyrimidine biosynthesis.

Most prokaryotes use a single carbamoyl phosphate synthetase (CPSase) regulated according to its dual metabolic function. This is illustrated by *E. coli*. CPSase, which is subject to allosteric control of activity by intermediates of both pathways and cumulative repression of synthesis by arginine and pyrimidines. The mechanism of the cumulative expression of the *Car Ab* operon encoding the nonidentical subunits of CPSase has been elucidated by Piérard and co-workers.

Piérard et al. have also shown that a significantly different situation prevails in fungi and in particular in *S. Cerevisiae* where they have found that carbamoyl phosphate synthesis is carried out by two independently regulated synthetases. CPSase P, the pyrimidine pathway synthetase, is part of a multifunctional protein confined to the nucleus; it is repressed and feedback inhibited by the pyrimidine. The arginine pathway synthetase, CPSase A, encoded by the unlinked *CPA1* and *CPA2* genes, is subject to both the general control of amino acid biosynthesis and specific repression by arginine. In a detailed study of the expression of gene CPA1, Piérard et al. found that the repression of this gene by arginine operates at the level of translation; i.e., regulated selection of the translational initiation code.

Gene Expression and Transcriptional Signals

M. Ptashne (Harvard University) presented some of his recent elegant studies on the control of transcription in eukaryotes and prokaryotes which indicate a common mechanism. The studies of Ptashne and coworkers showed that two principal molecular mechanisms govern the action of transcriptional activator proteins. The first concerns the interaction of regulatory proteins with DNA and the second, the mechanism of gene activation by a DNA-bound regulatory protein. He presented evidence that both of these descriptions apply to the regulation of gene expression in eukaryotes, as well as prokaryotes. His theory is novel and important for research on control of transcription, especially in eukaryotes.

W. Schaffner (Institute for Molecular Biology II, University of Zürich, Switzerland) spoke about enchancers and cell-type specificity of transcription. Enhancers were originally identified as long-range activities of gene transcription in higher organisms and were the first DNA sequences found to confer tissue specificity. Schaffner described his recent work on tissue-specific immunoglobulin (Ig) gene enhancers. He found that the enhancer is located 3' to the promoter and within the Ig transcription unit. The Ig heavy chain enhancer has the same characteristics as a typical viral enhancer: it works in both orientations and acts over long distances on heterologous promoters. In addition, it shows a pronounced tissue specificity, functioning only in lymphoid cells. The data obtained so far indicates that even small segments of the IgA enhancer exhibit cell type-specificity and are inactive in fibroblast cells. Schaffner et al. are continuing these important studies by analyzing the effect of point mutations within the active sequence elements in order to characterize the binding sites of tissue-specific transcription factors.

DNA Replication

The role of DNA gyrase in DNA super coiling as a regulator of bacterial gene expression was discussed by M. Gellert (Laboratory of Molecular Biology, National Institutes of Health, Bethesda, Maryland). Gellert et al. have studied, as a model system, the response of the genes for the two subunits of DNA gyrase (gyr A and gyr B) to changes in DNA. They found that the expression of both genes is strongly induced by DNA relaxation and remains high as long as the template DNA is held in a relaxed state. By recloning the gyr A and gyr B promoter regions, Gellert et al. have shown that DNA relaxation stimulates transcription initiation primarily and that the stimulation is a local and transferable property of short DNA sequence. A deletion analysis has put further limits on the extent of DNA sequence needed to maintain this form of transcription control.

S.D. Ehrlich (Institute Jacques Monod, Paris, France) and his group have been studying single-stranded circular intermediates in plasmid DNA replication. Their studies make it likely that many plasmids from gram-positive bacterial replicate via a single-stranded intermediate using a mechanism analogous to that of single-stranded DNA phages.

M. Radman (Laboratory of Mutagenesis, Institute Jacques Monod, Paris, France) discussed error correction in DNA replication. High fidelity of DNA replication results from enzymatic activities associated with the DNA replication machinery, as well as from past replicative mismatch correction. In studies with *E. coli* Radman et al. found that the efficiency and molecular specificity of the mismatch repair system suggests that it has two important genetic effects in DNA replication: it eliminates over 99 percent of spontaneous mutations arising as replication errors and, in so doing, equalizes the frequencies of diverse mutations along the DNA at a level of 10^{-10} to 10^{-9} per nucleotide replicated.

The specificity of mismatch repair is such that it compensates for the replication errors by repairing most efficiently the G:T, A:C, and frameshift mismatches and by repairing G:C-rich regions more efficiently than the A:T-rich regions.

Conclusion

The conference entitled "From Enzymology to Cellular Biology" was an intensive meeting with limited attendance. Molecular biological approaches to the study of enzyme structure/function relationships were emphasized. These approaches included, for example, protein (enzyme) engineering, recombinant DNA methods, and site-directed mutagenesis. However, more classical biochemical enzymatic studies were also presented and the need for a combination of research at both the biochemical and molecular biological level was stressed.

7/17/86

Computer Sciences

EARLY STEPS TOWARD AN OPTICAL COMPUTER

by J.F. Blackburn. Dr. Blackburn is the London representative of the Commerce Department for industrial assessment in computer science and telecommunications.

Heriot-Watt University, Edinburgh, UK, has made progress toward the ultimate realization of an optical computer. The three basic functions of a computer are arithmetic operations, logical operations, and the storage of information in what is called memory. In binary electronic mechanics these functions are achieved by devices that have two stable states. These two states have the value 0 and 1 in binary arithmetic operations and true and false in logical operations. Results from either are stored in memory in devices that are capable of two states.

For operation at high speed, computer devices must be switchable from one state to the other in a very short time. Such devices also need to be small, low in power consumption, and easy to fabricate. Electronic switches were realized through the vacuum tube until after the invention of the transistor in 1947. The transistor is made up of three layers of semiconductor materials. One outer layer is called the emitter and the other the collector. The center layer is called the base. A very small change in the current flowing from the base to the collector causes a much larger change in the current from the emitter to the collector. A large current from the collector can be regarded as 1 and a small current as 0. Structures that can carry out arithmetic or logical functions can be obtained by combining transistors and other electronic circuit elements.

To make an optical counterpart of a transistor one needs a semiconductor of light. Light attains its maximum speed of about 300,000 kilometers per second in a vacuum. In a transparent medium other than a vacuum the light is slowed by an amount that varies with the medium. The refractive index of a material expresses the ratio of the speed of light in a vacuum to its speed in the material. The slowing of the light is accompanied by a reduction of the wavelength, but the frequency remains constant.

The Role of the Interferometer

If we consider the optical apparatus called the Fabry-Perot interferometer we begin to approach the optical counterpart of the electronic transistor. This apparatus in its simplest form consists of two plane translucent mirrors placed parallel to each other and separated by a space. We may insert into the space a material that transmits light or radiation with the wavelength that we chose.

Each of the mirrors partially reflects and partially transmits the light that falls on it. When a beam of light strikes the mirror we can assume, for example, that 90 percent of the incident light is reflected and 10 percent is transmitted into the space between the two mirrors (cavity). Ignoring the material between the mirrors for the moment, we have 1/10 of the original light passing to the rear mirror as the forward beam. Then 90 percent of the forward beam is reflected back into the cavity as the reverse beam and 10 percent is transmitted through the rear mirror. So the transmitted beam has an intensity of 1/100 that of the original beam. The beam in the cavity rebounds from one mirror to the other, becoming progressively weaker, until all the incident light leaks out of the interferometer.

The forward beam and the reverse beam along with the successively weaker rebounds can be thought of as waves propagating through the cavity. If the incident beam enters the interferometer perpendicular to the front face all the beams travel along the same path. The

outcome of the interaction between the forward and reverse beams depends on the phase of the waves of the two beams--the relative positions of the crests and troughs. The alignment of two crests produces constructive interference and the alignment of a crest of one wave with a trough of the other is a destructive interference. Phases between these extremes are also possible. In the interferometer, full destructive interference produces near zero light intensity with negligible transmission. At full constructive interference the light in the cavity can reach 10 times the incident beam, and since the rear mirror transmits 10 percent of the light reaching it the interferometer transmits a beam equal to the incident beam.

The phase relations can be changed by changing the optical properties of the material in the cavity. This is comparable to changing the properties of the material in the base of an electronic transistor. A change in the refractive index of the material in the cavity will alter the phase relations of the beams in it by altering the wavelength. Thus a material can be selected to cause the forward and reverse beams to interfere either constructively or destructively.

The optical length of the material in the cavity is its physical length times its refractive index. It has been shown that full constructive interference results when the optical length is equal to an integral number times the half wavelength of the incident light. There are many possible optical lengths that yield full constructive interference. When the optical length falls halfway between distances corresponding to integral multiples of a half wavelength we obtain full destructive interference.

Since the intensity of the light transmitted through the rear mirror of the interferometer varies according to the phase relations of the beams in the cavity, it follows that the transmitted intensity varies with the optical length of the material in the cavity. The function that describes this variation between the optical length of the medium in the cavity and transmission of light from the rear mirror of the interferometer (defined as the ratio of the strength of the transmitted beam to that of the incident beam) is called an Airy function. This function is very important in the construction of an optical transistor. As the optical length of the medium in the cavity approaches a value corresponding to peak transmission, the transmission increases slowly until a threshold is reached and then suddenly increases very rapidly.

The effect of the refractive index on the optical length implies that the transmission of a cavity can be set at a fixed level by inserting into the cavity a material with the appropriate refractive index. Exchanging one material for another would change the transmission. What is needed, however, is a material with a nonlinear refractive index since it is not practical for the purpose of building an optical computer to exchange the material in the cavity for another.

Use of Nonlinear Material in the Interferometer Cavity

It has been found that when laser radiation is focused on certain materials the refraction varies with the intensity of the beam, which means the materials are nonlinear with respect to the refractive index. Therefore, with a nonlinear material in the cavity of an interferometer the refractive index can be changed by changing the intensity of the beam. With such a medium in the cavity a beam of laser radiation can be directed into the cavity. If the intensity of the beam is such that the refractive index yields an optical length in the region of the Airy curve between peaks, transmission will be low. If the intensity of the beam is slowly increased, the refractive index and with it the optical length gradually change and transmission of light increases slowly. At some point the refractive index and the light intensity in the cavity form a positive feedback loop--they become mutually reinforcing. At a certain critical level of incident intensity the feedback becomes strong enough to reach the steep region of the Airy curve and transmission suddenly spurts to a much higher level.

At the peak of the Airy function the ratio of the transmitted intensity to incident intensity is 1. But when the intensity of the laser beam is reduced somewhat from the peak value the transmission from the cavity does not fall to its initial low level because the light in the cavity is sufficient to keep the refractive index and with it the optical length near the values that yield maximum transmission. As the light intensity of the incident laser beam is reduced further, transmission still decreases only gradually. However, at some point the refractive index and the intensity in the cavity become mutually attenuating. At that point a small decrease in the incident intensity changes the refractive index enough to reduce the intensity in the cavity substantially. This results in a sudden sharp decrease in transmission. A plot of the intensity of the transmitted radiation against that of the incident beam is given in Figure 1.

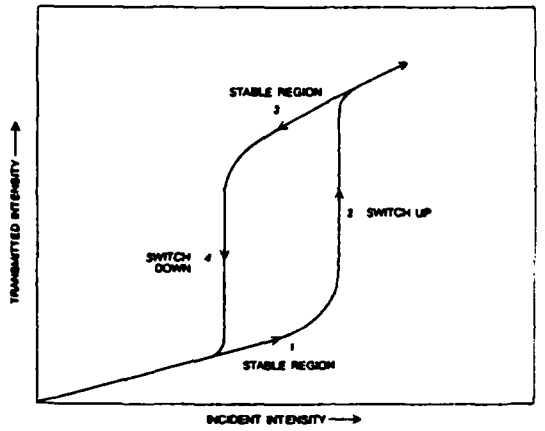

Figure 1. Intensity of transmitted radiation versus that of the incident beam.

On the rise at the threshold of the curve a small increase in intensity brings a sharp gain in transmission. On the decrease of incident light still in the higher stable region the transmission remains high until a second threshold is reached. At that threshold there is a sudden drop in transmitted light. A small drop of intensity greatly attenuates the transmission. An optical device that exhibits such a hysteresis cycle is said to be optically bistable because it has two stable regions where the transmitted intensity varies little with changes in the incident intensity. Thus a particular value of incident intensity can be associated with two levels of transmitted intensity. The actual transmission depends on the condition of the material in the cavity.

At Heriot-Watt the semiconductor compound indium antimonide, which has a highly nonlinear response to light, is used as the medium in the cavity. It is opaque to radiation in the visible part of the spectrum but is transparent to infrared radiation at some wavelengths. The source of radiation used is a carbon monoxide laser whose wavelength can be adjusted over a narrow range in the infrared part of the spectrum.

Much of the work at Heriot-Watt with indium antimonide has been done at 77°K. At this temperature the band-gap energy of indium antimonide is about 0.2 eV. Most other semiconductors have a much wider band-gap. Because of its narrow gap, indium antimonide has a nonlinearity between 100 and 1,000 times that of gallium arsenide.

The hysteresis cycle in the interferometer has application as a memory element because of its two stable states. Either state can be maintained indefinitely by a beam of intermediate intensity.

For information processing by a change in the optical arrangement the hysteresis loop can be narrowed or eliminated. This results in a single valued transmission curve, in which each level of incident intensity is associated with only one level of transmitted intensity. The shape of the single valued curve can be manipulated. In one shape the transmission is low and almost constant at low incident intensity. At a threshold the transmission rises steeply, reaching a high level that again remains constant as the incident intensity increases further. This curve is similar to the one which describes the current from the collector of an electronic transistor and is called a transphasor. Its operation is based on controlling the phase of the light within it and it is the basis of an optical transistor.

The Transphasor--A Switching Device

In the transphasor two precisely adjusted laser beams are focused on the same spot of a crystal of a nonlinear material like indium antimonide. The constant beam has a large and unvarying intensity. The probe beam has a much smaller intensity that can be modulated. The strength of the constant beam yields a transmitted intensity just below the steep region of the transmission curve. When the intensity of the probe beam is added to that of the constant beam the steep part of the curve is traversed and the transmission peak is reached.

The action is analogous to that of the electronic transistor. The constant beam is analogous to the constant "bias" current that flows from the emitter to the collector of the transistor. A small change in the base current in the transistor enables it to conduct a much larger collector current. Similarly a small change in the probe beam enables the transphasor to transmit a larger fraction of the incident radiation.

Like the transistor, the transphasor can be switched between two distinguishable states. The switching is extremely fast, probably a few picoseconds. A single transphasor could serve as an AND gate or an OR gate depending on the incident beams supplied to it. If the two incident beams are selected so that neither beam alone is sufficient to switch the device but together they are strong enough to do so, the result is an optical AND gate. Transmission is high only when both beams are present. If the incident beams are chosen so that either one is

capable of switching the device, the result is an optical OR gate. The transmitted intensity is high when either beam is present. A NOT gate can be constructed by using the reflected beam as the output. Since the reflected beam is the inverse of the transmitted one, increasing the incident intensity will yield low output and decreasing the incident intensity will yield high output.

The Heriot-Watt Demonstration Circuit

A series of all-optical circuits have been designed, constructed, and successfully operated at Heriot-Watt. These circuits demonstrate various primitive forms of an optical computer--for example, the finite state machine. In principle, a general-purpose computer can be fabricated by assembling many of these circuits together.

A demonstration circuit which demonstrates the parallel processing capability of light uses three independent information channels (see Figure 2). The circuit is powered by the green light from a Argon-ion laser. It requires no electrical connections. The light is divided into three beams by mirrors, and further divided by special holograms which form three light spots on each of the three optically bistable elements. These illuminated points (nine in all) act as the logic components on which the circuit is based. They are connected to each other by lenses which simultaneously direct the light reflected off each trio of points onto the next set. The same system could handle many more parallel channels by changing the special hologram.

The demonstration of principle is designed to show the transfer of data, in parallel, around a processing loop--performing an inversion in each full cycle. It exploits a technique in which the data is memorized by one set of optically bistable components before the next set is switched on to receive them.

Heriot-Watt uses a conventional microcomputer to control the clocking process. However, this could, in principle, be done optically. This arrangement allows a convenient interface to conventional electronics and, embryonically, indicates how optical methods may be included in electronic computers for special purposes. The control is an example of single instruction multiple data stream (SIMD) operation.

Comments

The achievement at Heriot-Watt of discovering very large nonlinearity in the response of indium antimonide to light was the key to their succeeding work on the optical transistor and the construction of circuits which demonstrate various portions of an optical computer in primitive form. The work to date, including the demonstration of a working model of data transfer around a processing loop, is very impressive.

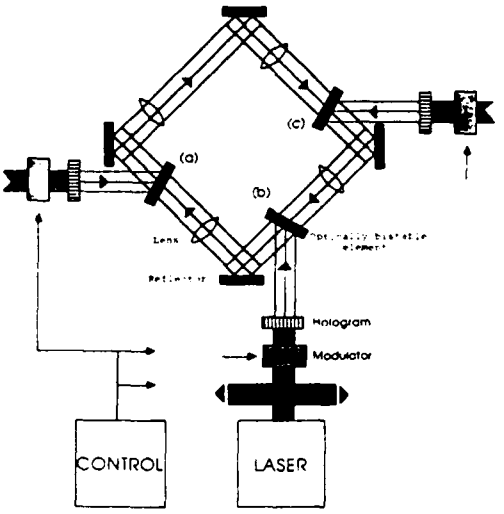

Figure 2. The Heriot-Watt demonstration all-optical parallel loop processor.

It is probable that within 5 to 7 years some parts of commercial computers may be optical for special processing functions. Indeed, some computers today use optical transmission to and from peripheral equipment. However, it is likely to be more than a decade before the mass production of all-optical computers.

Mass production of all-optical computers will be an immense undertaking. It will result in a change in all the working elements of a computer, a major change in the logical design of such a computer, and, most likely, a change in programing concepts to more massive parallelism than anything done today. If all of this is accomplished within the next decade it will be an extraordinary achievement.

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7/18/86

Mechanics

SYMPOSIUM ON FINITE ELEMENT METHODS AND FLOW PROBLEMS

by Eugene F. Brown. Dr. Brown is the Liaison Scientist for Fluid Mechanics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until September 1987, from the Virginia Polytechnic Institute and State University, where he is a Professor of Mechanical Engineering.

Introduction

The Sixth International Symposium on Finite Element Methods in Flow Problems was held in Antibes, France, from 16 through 20 June 1986. The symposium was organized by Institut National de Recherche en Informatique et en Automatique (INRIA), Avions Marcel Dassault Bréguet Aviation, and Electricité de France Laboratoire National d'Hydraulique. The objective of the symposium was to bring together researchers from both the scientific and industrial communities to discuss the theory and application of finite element techniques to the analysis of flow problems.

There were more than 200 in attendance at the symposium, with France, as might be expected, accounting for well over half the registrants and a smaller number of registrants, coming from the US, Scandinavia, the Benelux countries, the UK, and Japan. The symposium program consisted of invited lecturers, papers, and poster sessions contributed by 15 different countries devoted to the following themes (numbers in parentheses indicate total number of presentations in each area):

- Viscous flows (7)
- Turbulent flows (9)
- Thermoconvection (5)
- Compressible flows (15)
- Geophysical problems (4)
- Flows in porous media (2)
- Non-Newtonian flows (2)
- Combustion (5)
- Stability and bifurcation problems (2)
- Free surface flows (6)
- Spectral methods (10)
- Computational techniques (22)

Because the conference was organized into concurrently running sessions, I was unable to attend all the presentations. In this article I will principally be reporting on presentations in the areas of turbulent flows, compressible flows, and computational techniques. These seem to be the most popular topics based on the number of presentations given and, I think, represent the topics of greatest interest to the Navy. The papers which I will describe contain such features as nonstructured grids, automatic grid refinement, domain decomposition methods, the effects of compressibility, and the effects of compressibility and turbulence. Such advances as these indicate that "second-generation" finite element methods are fast approaching the level of maturity presently exhibited by the more popular finite difference and finite volume methods, and that they will soon have the capability of solving geometrically complex flows at realistic Reynolds numbers and Mach numbers.

A complete copy of the proceedings was distributed at the meeting. Selected papers will be published by John Wiley & Sons in its series, *Finite Elements in Fluids*.

Mesh Refinement

Professor O. C. Zienkiewicz (University of Wales, UK), who presented the first plenary lecture, has long been a champion of finite element methods and, in fact, organized the first of the present series of symposia. His position, not unsurprisingly, is that finite element methods now equal or exceed in performance finite difference methods. In addition, he claimed that their success is obtained without recourse to what he termed gimmicks. I think the truth in that statement lies in how you define a gimmick. Clearly, presentations given at the meeting demonstrated that not all finite element calculations are free of what Zienkiewicz might prefer to call "specialized procedures" which are required in order to get an acceptable solution.

The majority of Zienkiewicz's lecture was concerned with adaptive mesh refinement, that is, using local error estimates to make local modifications of the grid either by adding new elements by a process of subdivision, or by removing old elements. In principle, this method allows the automatic generation of a grid guaranteeing a preset level of error. Using local error estimates appears to be a more satisfactory procedure for adjusting the mesh size than using local property gradients, such as is done in finite difference methods, if only for the reason that the grid of refinement can be accomplished without the need for calculating additional variables. This procedure can be easily automated. Zienkiewicz showed the results of several two-dimensional calculations in which triangular

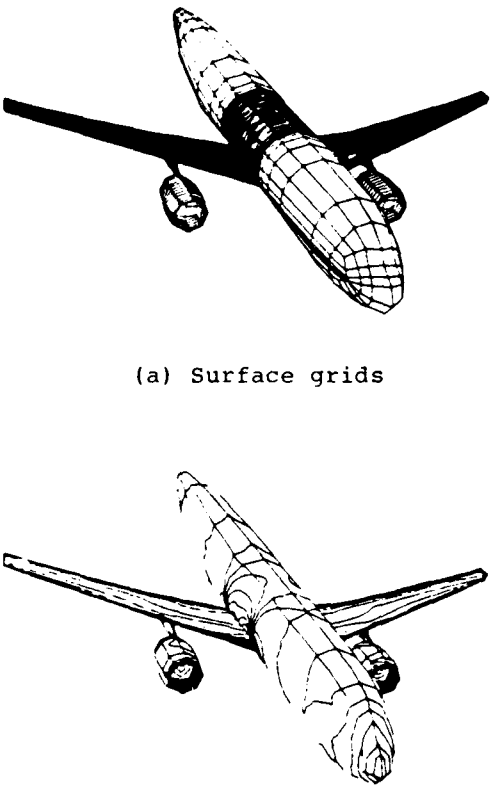
elements were used. These included flow over an expansion corner, supersonic flow over a hemisphere/cylinder at incidence, and an inlet calculation. Considerable sharpening of the shock waves was evident in the calculations. In order to avoid noise, however, the mesh refinement procedure needed to be controlled so that adjacent elements did not vary in size by more than a factor of two. In addition, some method must be used to damp the noise at shocks. Recent applications to transient situations have included the release of a store from an aircraft, and future developments will include the extension to three-dimensional flows.

Complex Configurations

The first of two "complete airplane" solutions was presented by Y. Vigneron of Aerospatiale in Toulouse, France. This was certainly the less ambitious of the two solutions from the standpoint of the gridding and the number of elements used; however, the calculations showed some interesting features. Potential flow was assumed and a preconditioned, minimal-residual method was used to solve the governing equation. The finite element discretization used a trilinear isoparametric approximation for the potential and the test functions and a piece-wise constant approximation for the density. Figure 1 shows the fuselage, wing, pylon, and nacelle geometry used in the calculations. It is clear that the mesh spacing is rather coarse. Only 20 to 25 thousand nodes were used in the calculations in order to conserve machine storage. A CRAY-1S computer with 1.7-M words of central memory was used for the calculations. Results were shown at a flight Mach number of 0.78, an angle-of-attack of 1.4°, and an engine mass flow ratio of 0.7. In order to calculate the boundary of the exhaust plume, Vigneron used a plume code developed at the Office National d'Études et Recherches Aerospatiales (ONERA) which couples an Euler solution inside the jet with an external potential flow solution. Approximately 20 minutes of CPU time was required to obtain a fully converged solution. Although the number of points used in the calculations is insufficient by a factor of 4 (in each direction) to obtain sufficient resolution of the flow field, a comparison of the effects of the nacelle, strut, and fuselage on the wing pressure distributions both inboard and outboard of the pylon seemed reasonable.

Several papers were devoted to the subject of Helmholtz decomposition (the Clebsch formulation) in which an Euler solution is obtained as a correction to the potential flow solution. The attraction of the technique is that with only minor modifications, existing, highly efficient, potential flow codes can be used to solve problems where rotationality is present such as in strong shock waves or in situations where rotationality is present in the upstream flow. The intention of this approach is to produce a more efficient computational procedure than conventional Euler calculations provide. Unfortunately, in no case was a comparison of computational times included nor a detailed comparison of relative accuracy made.

The first of the Clebsch papers was presented by F. El Dabaghi of INRIA. It concerned the proper treatment of the boundary conditions for the potential function and the rotationality correction function. His calculations for the flow over a swept NACA 0012 airfoil at a transonic Mach number under both lifting and nonlifting conditions succeeded in showing that his calculations have good entropy-preserving features in shockless flow regions, but they did not serve to demonstrate the accuracy of the solution. Responses to some questioning from the



(a) Surface grids

(b) Iso-mach lines

Figure 1. General view of the surface grids and iso-mach lines.

floor indicated that the recent GAMM Workshop on the Numerical Solution of Compressible Euler Flows in Paris revealed some discrepancies of his calculations with conventional Euler solutions. At best, I think, this approach might be an efficient substitute for conventional Euler solvers for subsonic and low weakly transonic conditions. Much work remains, however, before sufficient confidence can be had in its accuracy to consider it a serious competitor.

The presentation which exhibited the greatest number of second-generation finite element features was the finite element, flux-corrected transport (FCT) calculation presented by R. Löhner of the Laboratory for Computational Physics at NRL. His work combines a second-order Taylor-Galerkin approach which Löhner developed at the University of Wales with the FCT scheme developed at NRL by J.P. Boris. It is capable of handling both steady and nonsteady flows in geometries of considerable geometrical complexity. Convergence acceleration is produced by means of local time stepping and the use of multigrid methods. The algorithm can be implemented on unstructured meshes and includes an adaptive mesh refinement scheme. The significance of using the FCT algorithm is that improved shock definition can be achieved without resorting to the use of explicit artificial viscosity.

After giving a convincing argument for the use of finite element methods with unstructured grid capability, total variation diminishing (TVD) properties, and the capability of handling unsteady flow, Löhner showed a number of cases in which the FCT feature along with the adaptive mesh refinement combined to produce supersonic calculations with extremely sharp shock refinement. In addition to Mach 8 flow past a cylinder, Mach 2 flow past a nose cone, regular shock reflection from a wall, and Mach 3 flow past flat plate at a Reynolds number of 1000, his results included the much more geometrically demanding transient calculations of a shock incident on a missile launcher and a shock incident on semicircular depression. Three-dimensional calculations are in progress.

A good example of geometrical complexity was provided by the second of the "complete airplane" papers presented by T.J. Baker of Princeton University. The geometry used in his calculations was a complete Boeing 747 with 133,000 cells. Calculation were done at Mach number of 0.84 and angle-of-attack of 2.73°, requiring approximately an hour of computation time on a CRAY X-MP. In his presentation Baker concentrated on the mesh generation scheme. The starting point was the individual meshes created around the wing, fuselage, tail, and fin which were obtained by standard mesh generation techniques. The cloud of points resulting from these individual grids needs to be sorted out in order to produce the desired tetrahedral elements in such a way that the original aircraft geometry is preserved. This was done by means of Delaunay triangulation and the associated Voroni diagram. Once a grid was established, an already-existing Euler code with a multistage, time-stepping technique was used to integrate the governing equations. Convergence was accelerated by the use of local time stepping, residual averaging, and enthalpy damping. Details of the computed results have appeared elsewhere (Jameson et al., 1986) and were therefore not presented in this paper. Examination of the results have shown that even with 133,000 elements, the resolution of the calculations is insufficient. Probably from five to ten times more mesh points are required to get a sufficiently detailed solution. This will certainly require a CRAY X-MP with a large solid-state storage device (SSD) or a CRAY 2.

The Clebsch Approach

The second Clebsch paper was presented by A. Ecer (Purdue University, West Lafayette, Indiana). The Clebsch formulation used by Ecer differed from that of El Dabaghi in that the rotationality correction term is represented by the product of a material coordinate and the gradient of a Lagrange multiplier rather than by the curl of a rotation function. This has the advantage of greatly simplifying the boundary conditions on the rotational correction term. The calculations presented, however, only included the solution of the Euler equations and was specifically limited to transonic airfoils at high angles-of-attack. His solution is second-order accurate except in the vicinity of shocks where upwinding of the density is used in the supersonic regions. Using a mesh of only 120×20 grid points he was able to obtain good shock resolution, and plots such as that shown in Figure 2 showed that his solution exhibited good diffusive characteristics. Additional information concerning the details of these calculations can be found in a paper presented last March (Akay and Ecer, 1986).

The third of the Clebsch papers was presented by C. Lacor of the Free University of Brussels. It was similar to Akay's work except that a rotational function is used in place of the Lagrange multiplier. It turns out that this approach provides a consistent description

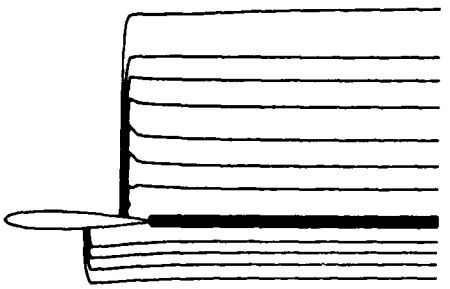


Figure 2. Contours of nondimensionalized vorticity/pressure values.

of the velocity field if certain conditions on the momentum equation and an unknown function, f, of the thermodynamic variables are met. The solution technique which employs a combination of a Galerkin and a Petrov/Galerkin method and includes a multigrid solver was used to solve the problem of incompressible flow in a centrifugal impeller. Since this is an invicid calculation it is not expected that the results will be in perfect agreement with experiment. Acknowledging this fact, Lacor judged the results to be satisfactorily close to the experiments.

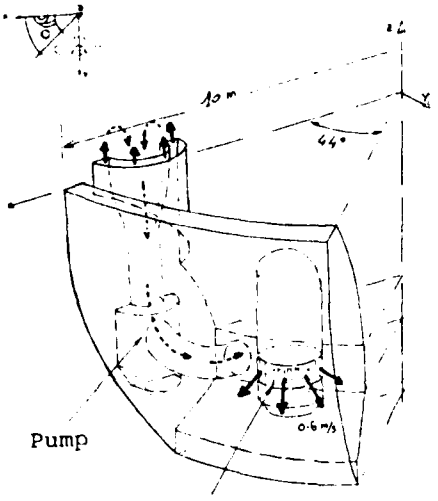
Turbulence

A.G. Hutton of Berkeley Nuclear Laboratory, Berkeley, UK, set the stage for a number of succeeding papers by reviewing recent progress in finite element calculations of turbulent flows. Investigators, encouraged by early successes of finite element methods for boundary layer flows, began about a decade ago to produce papers which reported turbulent flow calculations in increasingly complex geometries. These early investigators soon ran into trouble. Divergent solutions began popping up which could only be controlled by ad hoc fixes such as adjustment of the turbulence model constants. Following these difficulties, the number of finite element papers devoted to turbulent flows declined precipitously. Meanwhile, a way was sought to overcome the problems which were discovered. Hutton reported on several developments at the Berkeley Laboratory which have recently allowed such calculations to be made.

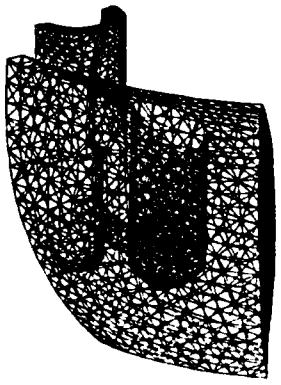
The difficulty was discovered to be the treatment of the source terms in the turbulence model equations which allowed extremely large turbulence kinetic energy values to be obtained in regions such as the corner of a sudden-expansion flow. Negative values of the dissipation arose which had the effect of rapidly increasing the turbulence kinetic energy to the point where the solution became unstable. To overcome this problem, Hutton's group has developed a new turbulence model based on the turbulence intensity and mixing length and a more careful treatment of the flow in corner regions. The constants in this new model were obtained by establishing a formal equivalence (under certain conditions) between this new turbulence model and the well-established k-ε model. Hutton showed three turbulent flow calculations which were chosen to test the effectiveness of the new turbulence model. These cases included an induction furnace, a reactor venting problem, and the flow in an electrostatic precipitator. In the case of the industrial furnace, Hutton's finite element calculations were actually superior to finite difference calculations. This he ascribed to the much reduced numerical diffusivity of finite element calculations. For the reactor case his calculations of entrainment agree very well with experiment. He said that future finite element work needed to be directed toward the development of affordable three-dimensional calculations, ways to efficiently extend the grid to the wall because of difficulties encountered with using wall functions, and the development of finite element methods employing Reynolds-stress turbulence models.

By far the most geometrically complex calculation which was attempted at the meeting was described by P. Lasbleiz of the Laboratoire Nationale Hydraulique, Chatou, France. It consisted of a 44° slice of the cold plenum of the primary circuit of the Super Phénix fast-breeder reactor. A general view of the geometry is presented in Figure 3 along with the associated grid. The cold, laminar flow simulation (Reynolds number=100) of this problem was done on a 1.5-M word CRAY X-MP 28 and required one second per 1000 nodes per time step. The gridding was obtained with the use of the commercial finite element generating program, Supertab. A mesh with almost 13,000 tetrahedrons and more than 20,000 velocity nodes was used. The solution scheme used was a splitting technique based on a weak form of the characteristics method. For a further discussion of this technique see *ESN* 40-4:136-138 (1986). Given the laminar nature of the calculations, reasonable agreement with experimental measurements was obtained.

R. Glowinski (INRIA and the University of Houston, USA) then presented a review of domain decomposition methods. Perhaps the first practitioner was Schwarz, 1890; however, his technique is not amenable to congugate gradient methods. Work within the last few years at



(a) General view



(b) Finite element mesh

Figure 3. Super Phénix cold plenum.

INRIA has concentrated on a least squares approach to overcome this difficulty. Glowinski reviewed both the displacement and the normal-stress controlled methods and showed some results which he had obtained using a domain decomposition method to calculate the viscous flow over an airfoil using an overlapping technique in which Navier-Stokes and potential flow solutions were combined. He presented Mach number, density, and vorticity maps to show that, in most situations, the domain decomposition results were indistinguishable from the (more expensive) calculations in which the Navier-Stokes were used throughout the flow field. Glowinski is organizing a conference on domain decomposition methods which will take place in Paris from 7 through 9 January of next year.

Another paper was presented by P. Ward (SDRC Engineering Services Ltd., Hitchen, UK). This paper concerned an extension of Akay and Ecer's method, presented earlier in the conference to three-dimensional viscous flows. The governing equations were first expressed in vorticity-transport form and were solved in the context of a Lagrangian functional which contained the velocity represented in terms of a new Clebsch transformation. The resulting variational formulation of the problem makes use of the total head, H, as the transported variable. The solution is obtained in terms of H and three Lagrangian multipliers. The advantage of this formulation of the problem is that it represents a unified approach to the solution of the potential, Euler, and Navier-Stokes equations. This means that viscous flows can be solved by using solution schemes previously developed for solving the Euler equations. Before the method is fully operational, additional attention will need to be given to the calculation of the shear stress terms. Apparently the method is still in its formulative stages and no results were shown.

Combustion

The first of the combustion-related papers was presented by T.E. Tezduyar of the University of Houston. He proposed a new finite element technique for steady-state, coupled, nonlinear, convection/diffusion/reaction equation systems. Schemes which he described for convection-dominated and reaction-dominated flows are intended to complement the Streamline Upwind/Petrov-Galerkin (SUPG) formulation which in some cases exhibits oscillations about internal and boundary layer discontinuities. To minimize such oscillations for convection dominated flows, a "Discontinuity Capturing Term" based on a one-dimensional analysis was added to the weighting function. This term, which acts in the direction of the gradient in the solution, depends on the spatial discretization and the variations in the solution. For reaction-dominated problems, a second-order term was added to the differential equation to minimize the oscillations about sharp gradients. The proposed formulation applied to standard test problems involving convection of a single component in a linear and a rotating flow field and a multicomponent, nonlinear, chemical reaction problem. In all cases the solutions were accurate, and the numerical dissipation and oscillations were minimal.

The development of a method to obtain accurate solutions of flame-front problems using a minimum number of nodes was presented by B. Larrouturou of INRIA,

Sophia-Antipolis, France. His paper was devoted to the numerical solution of a thermo-diffusion model which described the propagation of a wrinkled flame front in a gaseous mixture. The simplified reaction model uncouples the flame propagation from the gas flow but retains many of the essential features of the phenomenon, including the cellular instability of the flame. The combustion model neglects the dynamic compressibility of the gas and the effects of viscosity and gravity. In addition, the thermodynamic coefficients are assumed to be independent of temperature and species concentrations. The combustion is simulated by a one-step chemical reaction. An adaptive gridding procedure was developed in order to obtain an accurate and efficient simulation of the flame propagation. This is necessary because flame fronts represent thin layers in which sharp gradients occur. In these regions, the reaction rates exhibit a very strong nonlinear dependence on temperature. In such problems, disparate time and space scales appear, resulting in stiff partial-differential equations. These features lead to the most efficient grid being highly nonuniform. For this reason, a finite element approach is essential because of its demonstrated robustness on irregular meshes.

Larrouturou's adaptive gridding takes place in two steps: a dynamic rezone and a static rezone (see *ESN* 40-5: 173 [1986]). The dynamic rezone moves the grid with the flame front so that the flame front is deformed but always stays at the same place in the computational domain. The static rezone is performed at only a few time levels to avoid the accumulation of interpolation errors. It is controlled by the leading order terms of the truncation error. On a two-dimensional, wrinkled, flame-front calculation, this adaptive procedure produced a ratio of 25 in the size of adjacent elements and a ratio of 800 between the size of the largest and the smallest elements in the flow field. Figure 4 shows the detail of the nodal structure in the vicinity of the flame front.

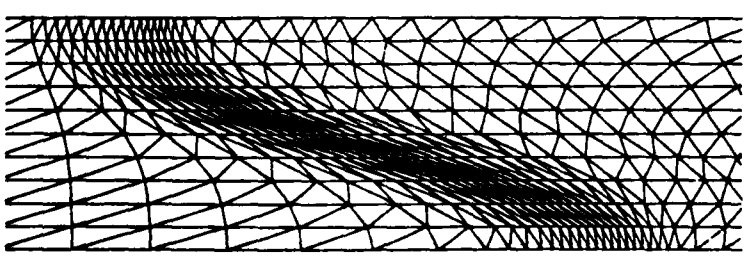


Figure 4. Nodal structure near the flame front.

Summary

This meeting served to demonstrate the far-reaching impact which finite element methods are having on the fluid mechanics community. Applications involving a broad spectrum of problems from weather forecasting to powder metallurgy were described. Impressive advances in the field are far beyond what might have been imagined at the first conference in 1974. This year, a particular emphasis was placed on the utilization of finite element methods in compressible flow problems, and impressive accomplishments were demonstrated in the use of mesh adaption techniques. It is likely that the next meeting, to be held in 1989 in Huntsville, Alabama, will contain a large number of papers demonstrating the effectiveness of the finite element methods for problems with complex geometry, and that a large number of applications will feature such mature capabilities as the inclusion of turbulent flows and flows with combustion.

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Ocean Sciences

18TH INTERNATIONAL LIEGE COLLOQUIUM

by Jerome Williams. Professor Williams is the Hudson Scientist for Oceanography in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until December 1987 from the US Naval Academy, where he is Associate Chairman of the Oceanography Department.

The 18th International Colloquium on Ocean Hydrodynamics, was held in Liège,

Belgium, from 5 through 9 May, 1986. Every May for the past 17 years a conference has been held at the University of Liège on some aspect of ocean hydrodynamics, and this year the theme was three-dimensional models of marine and estuarine dynamics. The organizers of the colloquium attempted to provide a forum for presentation of recent results involving three-dimensional hydrodynamic models along with a critical survey of appropriate numerical methods. The emphasis was supposed to be on regional models designed for specific well-defined basins, and participants were expected to have the opportunity to compare and discuss different approaches to the three-dimensional model, including multilayer and multimode models. Unfortunately, the estuarine aspects of the meeting objectives were not met. Comparison of what the organizers expected with what actually occurred showed a marked disparity in this area.

The papers presented at the meeting fit neatly into six groups:

1. Models constructed to fit existing data sets using large mesh sizes and large time scales such as seasonal or yearly averages
2. Models to fit boundaries and topography in shallower water
3. Models using small grid sizes and short time scales such as would be used in the study of estuaries
4. Mesoscale models used primarily in the description of ocean fronts and eddies
5. Various modeling techniques and caveats common to all kinds of oceanic models
6. General descriptive papers, usually describing work in progress or work contemplated where the presenter was hoping for discussion from the floor that would help him in model development.

Generally speaking, the papers were of good to excellent quality, and the discussion generated both in the conference room and in the corridors outside was at times quite lively. The American oceanographic community was well represented, and demonstrated its continued leadership in the area of numerical modeling, as reflected in my selection of the papers discussed below. A strong need for more basic information with respect to turbulent processes was demonstrated repeatedly, and there also seemed to be a lack of data taken for the express purpose of model calibration or model verification. Typically, data utilized were both vertically and horizontally widely spaced, data sets representing conditions at a specific time and location were not repeated, or data accumulated over a long period of time were averaged either over seasonal or yearly periods. I doubt whether these data are really applicable for use with the models discussed. The modeling community apparently is aware of these problems and is taking steps to develop data sets that would be more appropriate for their use. The recently established Institute for Naval Oceanography in Bay St. Louis, Mississippi, will probably focus on correcting this data problem as they develop new ocean models.

Large-Scale Models

Of the papers describing models developed to fit existing long-term averaged data sets, there were two that were unique. The first of these was by F. Martel and C. Provost (Université Pierre et Marie Curie, Paris, France) in which data taken in April and June of 1972 in the Gulf Stream/North Atlantic Current region by Clark et al. were examined to see whether or not Clark's hypothesis that the North Atlantic current was an extension of the Gulf stream was more valid than Worthington's assumption that the North Atlantic current was a separate current system. The developed model indicated that the Gulf Stream and the North Atlantic current seemed to be part of the same system.

The second paper described an attempt by P. Delecluse (Musée d'Histoire Naturelle, Paris, France) to use a primitive equation model to study the seasonal cycle of the tropical Atlantic Ocean. Due to the proximity of the equator, Coriolis force was neglected, leaving the wind field and sea-surface temperatures (from which heat fluxes were inferred) as the primary inputs. This model had some unique characteristics which reflected the strong and shallow thermocline and the rapidity with which changes occur in the equatorial region. Inputs included coast-line geometry but did not include topography. The model was run for a 6-month period with a constant wind stress before the seasonal wind stress variation was applied. It was apparent from the results that much improvement was needed in describing forcing functions, especially in describing effects of higher frequency phenomena. These higher frequency phenomena were present in the data but did not appear in the model predictions.

Shallow-Water Models

One of the salient features of the papers on shallow-water models was the attempt to have the models fit complex boundaries and topography such as would be found in shallow water. Y.P. Shang

(Aeronautical Research Associates of Princeton, New Jersey) suggested such a model for coastal and estuarine currents using generalized curvilinear grids. Although the usual equations were employed, the use of varying grid size and vertical sigma surfaces mapped into the regular grid made it somewhat unique. Shang also included waves but did not include wave breaking. Although the model was quite complex, it appeared that the payoff for the geometrical complexity was an increase in accuracy, especially for the short term and small grid size used.

The model of A. Blumberg (HydroQual, Mahwah, New Jersey) also included a more complex coordinate system in order to match both the topography and the dynamics. In this case, a stretched rectangular coordinate system with an irregular triangular grid was employed. This resulted in a curvilinear orthogonal coordinate system where the grid size and shape is a function of the velocity of the fluid and the bathymetry. A mode-fitting technique for waves was used to separate the fast external waves from the slow internal waves. This model was tested in both two- and three-dimensional cases using computer-generated examples but has not been tried with real data as yet.

A paper on a three-dimensional continental shelf hydrodynamic model including wave current interaction was of some interest because the author, M. Spaulding (Applied Science Associates, Wakefield, Rhode Island), has had a good deal of experience in modeling. Spaulding considered the fact that the presence of waves in shallow water induces boundary layer effects, altering the steady current field and increasing energy dissipation. The model was developed especially for the study of storm surges associated with tropical storms, so that atmospheric and hydrospheric effects are coupled. It has been used for a shallow-water environment under conditions where there is complete vertical mixing, where bottom friction is proportional to the square of the velocity measured one meter off the bottom, and where eddy viscosity is constant throughout the medium. Boundary conditions were determined by alternately doubling and halving the area of interest in order to determine under what conditions the model was least sensitive. The choice of a very low bottom-friction coefficient gave good agreement with the measurements, as did the assumption that the bottom stress increases with storm intensification. Spaulding postulated that this change in bottom stress was primarily due to resuspension of sediments, thereby affecting the bottom-stress coefficients.

Small-Scale Models

Although the objectives of the conference specifically indicated estuarine areas, there was only one paper directly concerned with the small grid sizes and time scales typical of the dynamics of these regions that I consider unique enough to discuss. This was a study by J. Krohn, K. Duwe and K. Pfeiffer (University of Hamburg, West Germany) of a three-dimensional baroclinic model of the Elbe estuarine system. The model was applied from the riverine region of no salt intrusion and no tidal variation to Elbe's mouth. The tidal range in the lower reaches of the estuary is between 2 and 5 meters, and the river discharge varies between an average of 400 cubic meters per second in September to 1200 cubic meters per second in April, resulting in currents up to a maximum of about 2 meters per second. Although the model is similar to others described at this meeting, Krohn et al. have successfully decreased the grid size to between 50 and 250 meters and the layer thickness to between 1 and 4 meters. This resulted in excellent predictions of water level and reasonably good current predictions.

Mesoscale Models

Mesoscale models were greatly in evidence, reflecting the strong interest of oceanographers worldwide in this scale size. Most of the papers presented, however, appeared to be a rehash of old material, but three papers stood out as being of more than passing interest.

A. Robinson (Harvard University) reported on modeling being done at many institutions at the present time, and he included some of his own work in mesoscale dynamics. He emphasized that the regional approach in the ocean is necessary, but from his work it appears that updating as rapidly as changes occur in the atmosphere is not required. His scheme involves systematic field estimation with dynamical interpolation where the forecast is melded with the observations and the model. In essence, there is a feedback loop in his model which constantly updates the model with current data. The Harvard open-ocean model has been applied to data from POLYMODE (a US-USSR effort in the Western North Atlantic, during which energy and vorticity analyses were initiated) to produce hindcasts which fit the POLYMODE data quite well.

At the present time Robinson is working in conjunction with C. Mooers (Naval Postgraduate School) on a program to study a portion of the California Current system in deep water. In attempting to predict major mesoscale features of this current system, they found that the

modules can be somewhat larger than initially thought; in this case about 75 kilometers was satisfactory.

Robinson has also applied his models to the Gulf Stream region, making forecasts for a week or so in advance (with encouraging results) in support of Navy operations. The model is initialized, including all rings present, and then allowed to run for a week. Cases were shown where double meander was predicted a week ahead of its actual development. One of the boundary conditions emphasized by Robinson was to include system feature history, especially when studying a dynamic system such as the Gulf Stream. Effort is now underway to fit the model into the Navy standard HP 9020 minicomputer for at-sea testing.

An entirely different type of model was presented by B. Hua, (Institut Francais de Recherche pour l'Exploration de la Mer, Brest, France). She attempted to model the change in eddy shape that occurs in certain parts of the North Atlantic due to a large influx of Mediterranean water at mid-depth. In general, the model developed by Hua showed the gross features of this eddy shape distortion; however, the model still needs more development.

A model designed to use data acquired from three stations at the edge of the Norwegian continental shelf in the North Sea was described by N. Heaps (Institute of Oceanographic Sciences, Bidston, UK). The model assumed that the viscosity-to-depth ratio was constant, although it allowed variation with wind-induced current. Steady-state wind conditions and a homogeneous water column were also assumed. The grid was about 30 kilometers in size, and the current readings from the three stations showed a reasonable fit with those predicted when depth-averaged values were used. One interesting aspect of this model was that the spectra of observed and modeled data do not show similar peaks. The model has an internal peak at about 14 hours, while the observed data do not show this peak at all. In addition, observations at the high frequency end of the spectrum were not reproduced by the model in accordance with the experience of P. Delecluse mentioned previously.

Modeling Techniques

As might be expected in any gathering of modelers, a good deal of time was devoted to various techniques that might be of help other modelers.

W. Holland (National Committee for Atmospheric Research, Boulder, Colorado) discussed some of these techniques in a description of a number of models he has developed over the years. These included a world ocean model with 12 layers and a horizontal scale of about 250 kilometers; a basin scale model capable of resolving eddies of about 25 kilometers in size with three to eight layers; and his newest, a regional ocean model that uses realistic geometry, is smaller than basin in scale, and has very fine resolution. He indicated that except for wind effects the assumption of potential vorticity conservation is somewhat in doubt. He also noted that the highly energetic current systems are dominated by mesoscale eddy variability.

Using an isopycnal coordinate numerical model, B. Boudra, R. Bleck, and F. Scholt (University of Miami, Miami, Florida) looked at transport fluctuations and meanderings of the Florida Current. Density surfaces were used as the vertical coordinate with a 2-kilometer grid size in the direction of flow while across the flow the grid size was variable. A channel width of 100 kilometers was assumed, emulating the bottom topography constraints of the Florida Current off the coast of Florida. The model had bottom stress decreasing linearly from the bottom to the surface, and bathymetry was included. An interesting aspect of this model is that instead of requiring spin-up the parameters were specified at the beginning so the model is effectively spun up at the start. The model indicated a strong conversion of potential to kinetic energy due to baroclinic instability. In general, the bathymetric features tended to stabilize the flow, but the wind effects apparently dominate. This application appears to be an excellent example of using a model to determine the major constraining features of a system.

In contrast, L. Roed (Det Norske Veritas, Oslo, Norway) and C. Cooper (Petroleum R&D Conoco Inc., Ponca City, Oklahoma) reported on the implications of open boundary conditions in wind-forced models. In this paper a warning was given to all modelers that the choice of boundary conditions could markedly affect the modeling results. Roed showed the effect of choosing different boundary conditions on a number of different cases and indicated that the response of the model was apparently sensitive to the type of open boundary condition chosen. His studies indicated that clamping, zero gradient, and sponge types of boundaries should be avoided. The probable best choice is an integrated characteristic boundary.

This was followed by a paper by D. Fandry (University of Tasmania, Australia) which reiterated what Roed had said, but where Roed had only used computer-generated data for his study of boundary conditions, Fandry used some real data, showing that the real problems were

similar to those discussed in the hypothetical case. Applying radiation conditions and using an offshore boundary with an infinite lateral dimension and clamped surface elevation, he found that the validity of the solution was related to the size of the domain and the time involved. There appeared to be no steady-state solution.

After these two papers, many of the attendees were somewhat concerned about the problem of boundary condition choice, and it appeared many would go back to their laboratories and run their own tests.

A theoretical study of tidal currents in which an attempt was made to isolate the frictional coefficient by mathematical means was presented by P. Dyke (Plymouth Polytechnic, Plymouth, UK). He was able to define a new parameter in terms of the friction coefficient, using a diffusion-type equation. This formulation of the frictional coefficient might very well provide some guidance for future work in determining the true nature of turbulent energy conversion.

The last two papers of interest in this group of modeling techniques were given by people from the Institute of Oceanographic Sciences (IOS), Bidston, UK. The first, by A. Davies, described a model using tidal forces at the boundary and wind stress at the surface for the waters around the UK. He predicted the frontal areas in this region by calculating the thickness of the bottom boundary layer. Davies found it necessary to use three different values of eddy coefficients--one for near surface, one for mid-depth, and one for deep water.

The second of the IOS papers was given by I. James, who spoke of the design of a general three-dimensional eddy-resolving model for stratified seas. During the discussion of this model, boundary conditions were again considered, and James suggested that no boundary condition is universally suitable. The choice of proper boundary conditions is apparently related to the specific type of model and the energetics of the dynamics present.

Descriptive Papers

There were two general descriptive papers presented--each concerned with a different area and each reflecting different concerns. The first area, the Great Barrier Reef off the eastern coast of Australia, was discussed by L. Bode (James Cook University of North Queensland, Australia) and J. Andrews (Australian Institute of Marine Science, Townsland, Australia). The authors indicated that there are some important practical problems in this region to be solved by adequate modeling. These problems are: an understanding of the transport of crown-of-thorns starfish larvae which is necessary to control their predation of coral, and the fact that the strong currents and dangerous bathymetry make navigation quite difficult. Bode and Andrews reported that due to strong tides and winds the water column in this region is well mixed, and two-dimensional modeling might very well be sufficient for many cases but certainly not for all. The problems suggested by the Australian group seem immense; obviously a great deal of modeling verification has to be done.

The other area, addressed by E. Salusti (University of Rome), was the Straits of Messina. Salusti indicated that the circulation through the straits is driven by the tide, and is so strong that small eddies are very often present that extend to the bottom and move with the flow, making the flow very difficult to describe. This was another example of a highly energetic system resulting in extremely complex flow patterns that would be very difficult to model.

Summary Remarks

In retrospect I believe this conference met some of its basic goals and objectives. Although very little new material was introduced, ideas were exchanged among modelers, and the strengths and weaknesses of various models were made apparent to all present. The directions for future work in the area of modeling, such as the better understanding of boundary condition constraints and the closer coupling of models and available data, were fairly well delineated. The fact that physical oceanographers need to support mathematical modelers was only too apparent as the conference progressed. Also of interest was the clear indication that there is relatively little work in estuarine modeling in progress at the present time. The apparent domination of the conference (strength of papers, if not in numbers) by American scientists is probably a pretty good indication of the relative activity of the American effort in ocean modeling as compared to that of Europeans. Proceedings of the conference will appear within a year, and will be published as usual by Elsevier in Amsterdam.

Physics

AN INTERESTING TOPICAL CONFERENCE ON INTEGRATED OPTICS

by Paul Roman. Dr. Roman is the Liaison Scientist for Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on assignment until September 1987.

A fine international get-together of experts, primarily from the world of technology and engineering, took place at Innsbruck, Austria, 16 through 18 April. The conference on Integrated Optical Circuit Engineering was held under the aegis of the rather large and quite long Third International Symposium on Optical and Optoelectronic Applied Sciences and Engineering. This symposium was organized jointly by the Association Nationale de la Recherche Technique (ANRT), located in Paris, and the International Society for Optical Engineering (SPIE), with headquarters in Bellingham, Washington. The popularity of these European symposia, now occurring at intervals of less than a year, can be gauged from the fact that the Innsbruck affair was attended by over 1000 participants from 36 countries. (But the majority came from West Germany, France, Austria, the UK, and Italy, in that order.)

The Innsbruck symposium consisted of 11 independent (and partly parallel) conferences. Over 400 papers were presented. In addition, 30 tutorials were offered in a continuing education framework. All the talks could not be accommodated in the modern congress center, so several conferences were delegated to other, nearby meeting halls.

Although it was possible for me to attend selected talks in several conferences, for sake of a focus I report here only on the conference on integrated optical circuit engineering. This was attended by 85 participants, and although there were occasionally some difficulties with the sound system and language barriers (all talks were given in English), communication was good and the atmosphere relaxed. Forty-six talks were presented, each 15 to 25 minutes long, with time for discussions (which tended to focus on technological details). The talks were well grouped into 10 nonoverlapping sessions, as listed below:

1. Lithium niobate technology
2. Ion exchange in glass
3. III-V compounds
4. Materials for integrated wave guides
5. Modeling and system design
6. Modulation and switching
7. Nonreciprocal and nonlinear integrated optics
8. Measurement techniques
9. Fiber optic and integrated sensors
10. Medium-IR waveguides

It is difficult for me to select what to report on in detail. My choice is based on presenting sessions (and, within these, selected talks) that were, in my opinion, the least technical. However, limitations of understanding or interest on my part also play a role. The arbitrariness of selection will be mitigated by the fact that the detailed proceedings of the conference can be now purchased; Americans may order them from SPIE, P.O. Box 10, Bellingham, Washington 98227-0010. Refer to "Innsbruck Symposium Proceedings No. 651." The price is $57, but members of SPIE can get it for $44. (Proceedings of the other 10 conferences are also available.)

Following is a survey of some presentations in Sessions 3, 4, 6, and 7.

III-V Compound Integrated Systems

The opening talk was given by a representative of a leading European research center in integrated optics: A. Schlachetzki (H. Hertz Institute for Communication Technology, Berlin, West Germany) who discussed topics in the still "touch and go" area of InP-based integrated devices. He focused on optical modulators and switches. These were fabricated in InGaAsP, lattice-matched to InP. The research which he described concerned the difficult problems related to the control of the refractive index and of the absorption coefficients.

A. Carenco (Centre National d'Études des Telecommunications, France) talked about more conventional systems realized with GaAs and GaAlAs. He pointed out that both single-hetero and double-hetero junction devices have both advantages and disadvantages that must be traded off against each other. He described recent progress in reducing propagation loss and in improving laser-to-waveguide coupling.

While also in the area of GaAs- (as well as InP) based systems, the talk presented by M. Erman (Laboratoires d'Électronique et de Physique Appliquée, Orsay, France) familiarized the audience with a rather recent approach to fabricate optical waveguides and phase-modulators. This process, called localized vapor phase epitaxy (LOCVPE), is selective and very unisotropic. The waveguide boundaries

which one so obtains are therefore rather smoothfaced, and this reduces scattering losses. In the more theoretical, second part of his talk Erman described how he and his coworkers constructed a computer model for phase modulators. The Helmholtz equation was used for the optical part of the problem and the Poisson equation for the electrical (transport) part. Finally, results were shown for different phase modulator structures that used LOCVPE doping.

The concluding talk of the session was given by G. Heise (Siemens AG, Neuperlach, West Germany) who talked about phase-shifted holographic gratings used for distributed feedback semiconductor lasers (DFB). This was fitting, because Siemens is now a leading European center in the development of DFB diode lasers. The gratings were generated in InP by holographic double-exposure interference techniques. This method is particularly suited for the laser-induced etching process, but photoresist techniques could be used also.

Materials for Integrated Optics Waveguides

In this group of talks, relative merits and problems of integrated optics devices made with different, mostly unusual materials were compared. Silicon-based, organic film, liquid crystal systems, and also thallium oxide on polymer film devices were discussed.

S. Valette (LETI/IRDI Institute of the French Atomic Energy Authority) advocated strongly the use of oxidized silicon substrate devices whenever truly complex integrated optical circuits are the goal. Chemical vapor deposition and multilayer technology are easy procedures. But liquid phase chemical deposition has also been tried with acceptable results. In most devices the French scientists had a Si_3N_4 layer sandwiched in, but they experimented also with doped Si layers. Silicon-substrate technology was found particularly useful for constructing passive optical components. As an example of one fine result of the group's work, Valette discussed the performance of an integrated spectrum analyser which they had built.

In an animated and highly pedagogical talk D.G. Vass (University of Edinburgh, UK) described calculations that aimed to determine the variation of light intensity when light is transmitted through a twisted nematic liquid crystal cell mounted between polaroids. The "twist" was assumed to be achieved by appropriate microgrooving of the cell walls. This will lock the polarization unless the voltage on the cell is beyond a critical value. The variation of the transmitted intensity was calculated as a function of the amplitude of the cell-activating voltage signals. Vass mentioned that the Edinburgh group has already built such experimental liquid crystal devices with an area of 200 μm^2 and will attempt to reduce this to 50 μm^2.

H. Franke (University of Osnabrück, West Germany) talked about the fabrication of organic lightguide structures. A polymer matrix, a benzoine-type photoinitiator (such as the Darcur polymer), and a chlorobenzene solvent were used in the experiments. If the photoinitiator concentration was sufficiently high, simple exposure to soft ultraviolet light led to refractive index changes up to $\Delta n=0.03$. The resulting patterns were then thermally developed, whereby Δn increased to 0.05; finally, fixation ensued. The researchers interpret the process as a photo-induced self-condensation.

There was another talk in the area of organic waveguides: H. Franke reported on optical waveguiding in polyimide, research which was done while he visited the IBM Research Center, La Jolla, California.

Modulation and Switching

This was really a double session, apparently catching the interest of many researchers. Frankly, in my opinion, there was little new or basic in these presentations. Most talks were concerned with $LiNbO_3$ devices, and they were predominantly about theoretical studies.

Two British groups reported on integrated traveling wave modulators based on $LiNbO_3$ systems. The first, summarizing General Electric Company Research Laboratory computations, was presented by N.J. Parsons; it emphasized designs for bandwidths in excess of 20 GHz. The second paper, work by University College (London) researchers, was read by D. Erasme; it dealt with questions relating to phase-reversal electrodes.

Two communications from the University of Dortmund, West Germany, discussed the successful application of the beam propagation method of calculation for various electro-optic devices, primarily crossed waveguides and switches, based on $LiNbO_3$. The calculations used also an effective index methodology. The first paper was presented by M. Mevenkamp, and the second by J. Čtyroký, a visiting scientist at Dortmund from the Czechoslovak Academy of Science, Prague. Čtyroký also noted that the reproducible devices fabricated at Dortmund showed characteristics that closely approached the theoretically calculated limits of performance.

J.W. Parker (STC Standard Telecommunications Labs, UK) reported on a new method that can be used to construct a polarization-independent integrated optics modulator. The "trick" is achieved by applying a novel electrode arrangement. The calculations showed that, while this design achieves a high degree of polarization insensitivity, it does not require impractical modulation voltages or severe alignment tolerances.

Fiber-optic gyroscopes demand a very high spectral-purity input. This practical requirement led C. Schaefter and his colleagues (Technical University of Berlin, West Germany) to make optimization calculations for a surface acoustic wave (SAW) Bragg modulator. The innovative element is the application of properly tapered traveling-wave waveguides, with the SAW field passing in between. The calculations show that for the ideal case of a Gaussian beam, the suppression of unwanted frequencies will be greater than 60 dB below the desired shifted frequency wave. For realistic field distributions, 20 to 30 dB suppression should be quite easy to achieve in practice.

There was an interesting episode at this session: a scheduled speaker, representing the Bulgarian Academy of Sciences, did not turn up and, thus, perforce, her paper on integrated optics multimode components in an $LiNbO_3$ device was withdrawn.

Nonreciprocal and Nonlinear Integrated Optics

Personally, I found this session the most stimulating, primarily because it concerned itself with novel, only partially tried ideas, and because most of the talks were related to each other.

Actually, there was only one talk on nonreciprocal devices: H. Dammann (Philips GmbH, West Germany) discussed nonreciprocal waveguides based on the Faraday effect. The practical motivation for such devices is that they may serve as optical isolators or circulators, and may play an important role in forthcoming, more advanced fiber communication and fiber sensor systems. Damman's talk, naturally, involved a material that had not been discussed in the special session on materials for integrated optics, namely, yttrium-indium garnet (YIG). He first gave a very fine general presentation on magneto-optic waveguides, pointing out that the simplest structure, YIG on a gallium-gadolinium garnet (GGG) substrate, would be a highly multimode device. In order to have single-mode systems, it is necessary to have both above and below the YIG a cladding layer (which contains Pb-admixture to the YIG) and a Co-YIG buffer on top of the GGG substrate. Subsequently, he described in detail the actual manufacturing process, pointing out that, instead of the basic YIG, a "modified YIG," $Y_{3-x}\ Pb_xFe_5O_{12}$ was used. The Pb content for the cladding and core region was varied by altering the speed of rotation when the sample was grown in the liquid phase epitaxy process.

The introductory talk to the papers on nonlinear integrated optics systems was given by B.R. Hampel (University of Paderborn, West Germany) who, in a very clear presentation, reported on the first successful observation of optical parametric fluorescence in a guided-wave structure. The experimental device was a simple Ti-indiffused $LiNbO_3$ channel waveguide. When pumped with light of frequency ω_p, the second-order nonlinear effects will give rise, in the output, to a very small amount of a signal-frequency component (ω_s) and an idler-frequency component (ω_i) (in addition to the strong transmitted ω_p component). Of course, $\omega_s+\omega_i=\omega_p$ and the phase matching condition $k_s+k_i=k_p$ must be satisfied. In calculating the expected fluorescence, the ω_s and ω_i components must be treated quantum theoretically because they are so weak. Several possibilities have to be taken into account. The signal- and the idler-radiation may both be guided; both may be in the substrate modes; or, finally, the signal can be in a guided- and the idler in a substrate-mode. These circumstances determine the width of the fluorescence spectrum, which was discussed in detail. The experimental results agreed with the calculations extremely well. The fluorescence was studied as a function of the pump wavelength (mainly in the red), of the pump power, of the waveguide temperature, and of spatial filtering (achieved with a section of monomode fiber.) With sufficiently high pumping powers the scientists observed exponential growth in the fluorescence power: this indicated that it will soon be possible to obtain stimulated emission, that is, to construct an integrated optics parametric device.

Studies of how best such a parametric oscillator could be made, were conducted by G.P. Bava (Polytechnic of Milan, Italy) and coworkers. Bava analyzed simple Ti-indiffused, and Ti-indiffused proton exchanged, resonating structures with a view to minimizing the pump threshold power. The effect of crystal orientation on the phase-matching condition was also discussed.

More about the achievement of phase-matching (which seems to be the greatest difficulty) was said in the talk by B. Jaskorzynska (Institute of Optical Research, Stockholm, Sweden). She explained

that in their institute experiments are under way aiming to replace the exact phase-matching condition by a mismatch-compensation technique. This approach is based on using a periodic structure, and compensating to the mismatch by the momentum $2\pi/\Lambda$ corresponding to the period of modulation (Λ). The particular periodic structure studied in Stockholm was a $LiNbO_3$ waveguide where, instead of a continuous Ti layer, a system of parallel Ti stripes have been arranged (perpendicularly to the line of propagation). Calculations of the second harmonic generation in such a periodic-structure waveguide were carried out for the case where simultaneous modulation of both the linear and nonlinear properties is admitted. Experimental studies were successfully conducted for the regime where only the linear properties were modulated. In addition, very recently the researchers also succeeded in demonstrating (in this regime) the generation of the second harmonic, although it occurred with an extremely low efficiency. Stronger modulation (when the nonlinear properties also became modulated) will, according to the calculations, raise the efficiency drastically.

There was one more contribution to this session: B.K. Nayar (British Telecom Labs, UK) talked about the design of efficient organic crystal-cored (glass-cladded) fibers for parametric interactions. The reasons for advocating organic materials in this context is that they may have 100 times higher nonlinear coefficients than $LiNbO_3$, have a higher damage threshold, and can be optimized by molecular engineering. In the talk, the fulfillment of phase matching again received special interest. The calculations indicate that biaxial birefringent crystals with a controlled orientation seem to be the most promising core materials. Numerical calculations were carried out for the example of a meta-nitroaniline, although other (unnamed) materials are expected to be more efficient. Preliminary experiments successfully demonstrated second harmonic generation.

Concluding Remarks

The majority of speakers and participants at the conference were middle-echelon (hence, mostly, middle-aged) R&D personnel from the big industrial and quasi-governmental research laboratories. But universities that in recent years had the initiative to create good industry-university cooperation and already had good engineering-technical basic facilities were also well represented. This was particularly conspicuous with regard to West Germany.

While the level of talks was consistently high (even if some sessions focused on very down-to-earth technologies), the same can not be said in regard to the presentation of the material. Perhaps in Europe people in industry are less skilled in constructing and delivering effective talks than are their colleagues in academia, whose performance techniques I find consistently superb in this part of the world.

I feel that the conference served quite well the purpose of exchange between practitioners in industry and scholars in more basic research. In addition, extensive international interactions took place; these were well evidenced also outside the lecture rooms. The beautiful Alpine surroundings and the ancient city equipped with modern facilities certainly helped.

5/22/86

THEORETICAL WORK ON LASER-INDUCED SCATTERING, ATOMIC PHYSICS, AND WIGGLER DESIGN AT INNSBRUCK

by Paul Roman.

The research group for Physics of Electromagnetic Interactions, a unit of the Institute for Theoretical Physics, University of Innsbruck, Austria, produces a steady stream of high-quality research in the areas of scattering processes in the presence of strong electromagnetic fields; interaction of atoms with laser radiation; plasma stability; and classical radiation theory in strong fields and for relativistic charged particles. The group's sustained efforts deserve special commendation, the more so since, despite having moved recently into a magnificent (and partly unused) science building outside the town, the institute suffers from extremely severe fiscal constraints (to a larger extent than the average Austrian university departments). They make up for the deficiencies by arranging for meaningful cooperation with foreign research centers; there is a strong emphasis on communist countries (including the USSR), but other European countries (France, Italy), as well as the US, also figure in cooperative projects and personal exchanges.

In the following I describe selected activities that particularly caught my

imagination. These topics are in the area of scattering in strong external fields, Rydberg thresholds and Rydberg wave packets, quantum jumps, and calculation of complicated wiggler fields.

Scattering in Strong Fields

This work is under the personal direction of Professor F. Ehlotzky, who is also the director of the entire research group.

In general, Ehlotzky's research thrust is toward the development and application of a unified quantum-field-theoretic description of scattering and absorption processes in the presence of strong, coherent electromagnetic fields. His latest study, (currently in press, *Physical Review A*) reconsiders a deceptively "simple" process, the potential scattering of electrons in a strong laser field. This process is important because, among other areas of possible relevance, it is one of the main mechanisms in laser heating of plasmas. The low-frequency behavior of these phenomena was considered first by Kroll and Watson (*Physical Review A8*, 804, 1973), who established a relation between low-frequency laser-assisted scattering and the corresponding cross sections of the elastic processes. Ehlotzky's most recent work (done in cooperation with J. Bergou, Hungarian Academy of Sciences) investigates the deeper physical meaning and the range of validity of the Kroll-Watson theorem. In this research the laser beam is described by a quantized single-mode plane-wave field, with a finite number of quanta in the mode. Not unexpectedly, the scattering amplitude is expanded in powers of the potential, and only the first two Born terms are considered. (Reasons are given why this should be satisfactory.) The central result of the study is that, from this calculation, in the limit of an infinite number of field-quanta, the Kroll-Watson approximation is recovered. In the process, additional information and insight is gained into the validity of this typical low-frequency theorem. As a one-time quantum-field-theorist, I find it very beautiful that, even though the problem may be treated in the framework of formal scattering theory (which I always found a remarkable edifice), Ehlotzky chose to use the elegant formalism of particle-dressed field states.

Ehlotzky's interest in working with such states goes back for a couple of years. In one interesting line of research, he investigated two nonrelativistic scattering problems from a unified viewpoint, viz., scattering of light by a free electron, and scattering of electrons by a screened Coulomb potential. It has also been assumed that (in both cases) the electrons involved in the scattering process are embedded in an intense microwave field and a strong, static, homogeneous magnetic field. Under these circumstances it is necessary to describe the particles by exact field-dressed states. On the other hand, the basic scattering processes may be treated in lowest order perturbation theory. With this approach, the induced nonlinear processes can be discussed in a transparent and appealing manner. Compact analytic expressions for the cross sections can be obtained.

Atomic Physics and Quantumoptics Research

This activity is led by Dr. P. Zoller. Apart from "conventional" work on atomic beam cooling and radio-frequency ion traps, Zoller recently stepped up his front-line research in three areas: Rydberg thresholds; Rydberg wave packets; quantum jumps.

Rydberg Thresholds in Laser Fields. In the standard two-level-atom model, which describes the resonant interaction of laser radiation with atoms, the coupling between the two resonantly coupled atomic states is treated exactly, while excitation of all other nonresonant atomic levels is either ignored or calculated in perturbation theory. Since a necessary condition for the validity of this approximation is that the Rabi frequency of the resonant atomic transition be much smaller than the separation to the neighboring states, excitation near a Rydberg threshold cannot be treated in this way. Indeed, in this case one ought to consider the mixing-in of an infinite number of bound states converging to a threshold, as well as the adjacent continuum states. At the 6th Polish School on Coherent Quantum Optics, September 1985, Zoller suggested that the difficult problem of Rydberg thresholds in laser fields may be solved by treating the interaction of the Rydberg electron with the laser radiation in the continuum above threshold and then extrapolating this scattering information by analytic continuation to the bound part of the Rydberg series. (My personal discussion with Zoller led to the agreement that "analytic continuation" is not quite the correct term from the strict mathematical point of view.) The essential feature of Zoller's approach is that it considers the interactions with the entire Rydberg series (as opposed to treating the interaction with each Rydberg level separately). This interaction can be characterized by a few parameters. In the actual calculations the well-developed formalism of scattering theory with Coulomb functions plus additional short-range potentials (the so-called multichannel quantum defect theory) was

employed--this is the first application so far of this formalism outside the area of parametrizing configuration mixing of many-electron atoms.

Quantum Jumps. Let us consider fluorescence from a three-level system in a V-configuration (Figure 1), where the state $|2\rangle$ is metastable. Suppose the system is driven by two lasers at the "strong" and "weak" transition lines respectively. Most of the time the atom emits fluorescent photons on the "strong" line. Recently Cook and Kimble suggested that the quantum jumps of the atomic electron from the active two-level system [$|0\rangle$, $|1\rangle$] to the metastable state $|2$ is reflected by the occurrence of emission windows on the strong transition line. While, intuitively, this semiclassical statement is plausible, closer inspection of the basic formalism of quantized states stimulated Zoller to discuss the processes in a strict quantum-statistical framework. In the first weeks of April, the study produced an exact expression for the conditional probability density that governs the time distribution of photon emissions, and this leads to an understanding and an interpretation of the presence of photon emission windows. A computer simulation has been performed, and Zoller jubilantly told me that the experimental verification of his calculations had just been privately communicated to him from colleagues in the US.

Wave Packets. Zoller's current preliminary work is once again related to Rydberg states. Cooperating with two undergraduate students, he is investigating the generation and detection of Rydberg states by the excitation of electrons from a low-lying atomic state with a short (picosecond or shorter) pulse to a Rydberg state. The model of the study is a time-delayed two-photon experiment where a first laser pulse generates a wave packet which is then probed by a second short pulse. The careful calculations clearly indicate that the two-photon transition probability will show peaks wherever the time delay between the pulses is a multiple of the classical orbiting time. Zoller developed a semiclassical formalisms to describe the motion of the wave packet and to analyse the time-delayed two-photon process. It is remarkable that, within this framework, the highly abstract formalism of quantum mechanics related to wave packets can be made explicitly (and experimentally) manifest in a very simple manner.

Emission Spectra from Strange Wiggler Fields

Dr. C. Leubner has a longstanding interest in exact, yet practically feasible calculations which are needed to determine the accurate emission spectra from relativistic electrons that pass through a prescribed strong, static magnetic wiggler field with arbitrary variation. The detailed prediction of the spectral and angular distribution of the radiation from a single electron that traverses a planar strong-field wiggler is determined by an integral-expression that was presented in the 1960's, many years before anyone talked seriously about enhanced spontaneous synchrotron radiation (not to mention free-electron lasers). The theory was described by Jackson in his now classical textbook *Classical Electrodynamics*. The trouble is that the evaluation of the integral is far from trivial. Standard methods of calculation (based on an expansion in terms of a sum over products of Bessel functions) require an inadmissible timespan on even the newer supercomputers for all but the simplest (idealized) field distributions. In order to permit more sophisticated calculations, Leubner developed an entirely new approach. This is a "modified saddle-point method." In essence, he devised an easily programable technique for the uniform asymptotic expansion of certain types of contour integrals for the case when one of the critical points is an endpoint of the interval of integration. This method (which obviously has applications beyond the wiggler problem) may be considered as an alternative of what the specialists call the Bleistein method; it was described recently in the Europhysics journal, *Journal of Physics A: Mathematics and General*, 19 (1986), 329. Subsequently, Leubner and his student, H. Ritsch, used the procedure to calculate the spectral and angular distribution of the single-particle wiggler signal for various test cases when the wiggler magnetic field has an arbitrary functional behavior in the coordinate along the wiggler axis. By comparing his results with the tedious numerical calculations (that took over one-half hour on a Cyber 74), Leubner ascertained that his method is very efficient (the typical computer time was around 0.1 sec., even without optimization of the Fortran code) as well as

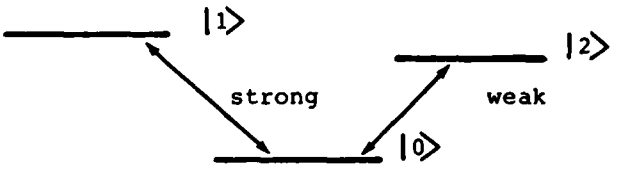

Figure 1. Three-level V-system.

accurate, especially in the most interesting range of frequencies around the characteristic frequency of the wiggler.

Future plans center on three areas. First, it will be rather easy to accurately compute the radiation from an electron traversing a sequence of wiggler segments with parameters that vary from segment to segment. Second, and more importantly, calculations are under way to determine the radiation from (more realistic) wiggler fields which, in addition to the sinusoidal variation along the axis of the beam propagation, also have a transversal variation. (In the present model, the transversal variation is assumed to be a hyperbolic sine function, and special attention is given to calculate the effect on the electrons that pass through the field at the "edges.") Third (and I find this particularly exciting), Leubner is taking up a challenge suggested by Soviet scientists from Novosibirsk. The researchers suggested that (using superconducting magnet technology) a wiggler should be built where, instead of the usual quasi-sinusoidal variation along the direction of electron propagation, a periodic pattern (20 or more units in length) with very sharp peaks would be employed (see Figure 2). The basic theory of synchrotron radiation with undulators asserts that such an arrangement should yield strong high harmonics (i.e., UV or even XUV radiation) as well as small beam divergence. The Soviet scientists used a rule of thumb to calculate the critical frequency (and hence the details of the emitted radiation) from such an arrangement. But Leubner has serious doubts as to whether the usual formula, valid for smoothly periodic wiggler fields, can be extrapolated to the suggested field pattern. He is going to do the exact calculation (using his fine method of uniform asymptotic expansion of integrals with coalescing end-point and saddle points, and assuming a Gaussian shape for the peaks). He adds that the calculation cannot be done with any other, conventional, methodology.

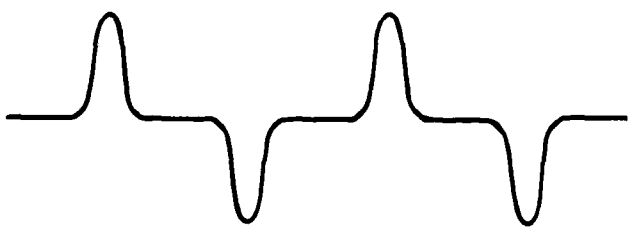

Figure 2. Russians suggest novel wiggler field.

7/21/86

News and Notes

A VISIT TO THE LABORATORY OF FLUID DYNAMICS AT THE UNIVERSITY OF VALENCIENNES

Valenciennes is located in Northern France approximately 100 km southwest of Brussels. I visited the Laboratory of Fluid Mechanics which, along with a similar Laboratory of Solid Mechanics, makes up the Study and Research Group in Mechanics and Energetics (GERME). The laboratory staff consists of 15 people: five Ph.D. candidates and 10 third-year, diploma-course students. My hosts were Professors P. Florent and C. Tournier.

The University of Valenciennes is relatively new, having been built in the mid-1960's as a University Institute of Technology. Its strength continues to lie in the applied sciences area with approximately 5000 of its current 6000 day students electing technology-related studies. In addition, the university has a sizable evening program in which 4000 technicians are currently pursuing degree-related studies.

Professor Florent, who, incidentally, worked for DTNSRDC between 1961 and 1965, showed me his new low-speed wind tunnel which he built with funds provided by the local government and the Direction des Recherches Études et Techniques (DRET) of the French Ministry of Defense. It has a 60×60-cm^2 test section and a maximum velocity of 60 m/s. It was designed in order to carry out wake/structure interaction experiments involving tandemly positioned airfoils. It features a large contraction ratio (30:1) and a low turbulence level (0.05 percent). The tunnel is currently in the shakedown stages, construction having been completed only in January. It shares a two-channel, TSI, 2-beam, LDV system with an adjacent, yet-to-be-constructed tunnel designed for heat exchanger studies.

Florent's future plans involve using this tunnel to make hot-film and LDV measurements on an ellipsoid of revolution at moderate incidence. At the present time he has a EEC contract to investigate asymmetric stern designs in collaboration with the Hamburgische

Schiffbau Versuchsanstalt (HSVA). In connection with both projects, similar experiments by Tournier will be conducted in the new polarographic tunnel.

In a polarographic tunnel, electrolysis currents are measured from which the wall values of the velocity gradient magnitude and direction are obtained. This technique was originally proposed in the 1960's by Hanratty of the University of Illinois (Mitchell and Hanratty, 1966). The advantage of the technique is that measurements at the surface itself can be made and, because the probe is completely flush with the model surface, the measurements are completely free of probe or probe support interference. The facility consists of a water tunnel containing a weak electrolytic solution of potassium and iodide ions. A heat exchanger must be included in the circuit in order to maintain the temperature to within ±0.1°C because the constant of electrolytic diffusion is strongly temperature dependent. Their first tunnel, on which results were first reported in 1978 (Tournier and Bernard, 1978), had a 15×15-cm^2 test section and a maximum velocity of 1 m/s. Extensive investigations were made in this tunnel of the flow around a circular cylinder. The probe was a split-film electrode consisting of two platinum ribbons 0.5×0.1 mm^2 in cross section separated by a strip of 8-μm-thick Mylar and machined flush with the model surface. Determination of the wall velocity gradient and its direction involves measuring the electrical current to the two halves of the twin electrodes and electrically amplifying and combining the results.

The technique seems to be limited to steady or at best quasi-steady flows. Results have recently been obtained on an oscillating cylinder/fin combination to study heat transfer enhancement techniques. However, when the oscillatory component of velocity is large or the frequency is high, frequency response problems appear. Work is currently being directed toward a better understanding of the limitations of the technique under these circumstances.

Just nearing completion is a new 30×30-cm^2 polarographic tunnel having a maximum velocity of 4 m/s. The purpose of the new facility will be to obtain high enough Reynolds numbers that direct comparison of results can be made with Florent's new wind tunnel. This will allow measurements obtained with conventional (hot-film and LDV) techniques made in the wind tunnel to be directly compared with electrochemical measurements. In this way the effect of interpolation (required to get wall values of the velocity gradient with LDV techniques) and the effect of the probe and probe support interference (present in hot-film measurements) can be assessed.

The results of Tounier's most recent work will be published in the proceedings of a forthcoming AGARD Fluid Dynamics Panel Symposium on Aerodynamic and Related Hydrodynamic Studies Using Water Facilities, to be held in Monterey, California, from 20 through 23 October 1986. The title of the paper by C. Tournier will be "Mesures en Tunnel Hydrodynamique par Méthode Électrochimique."

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Eugene F. Brown
7/18/86

A EUROPHYSICS CONFERENCE ON HIGH-POWER LASERS

The European Physical Society's Quantum Electronics Division sponsored a 4-day conference in April on high-power lasers and their industrial applications. This international meeting, attended by about 200 participants, was one of the 11 conferences that took place within the framework of the Third International Symposium on Optical and Optoelectronic Applied Sciences and Engineering, in Innsbruck, Austria (see page 352). Most of the speakers (and probably most of the audience) came from West Germany in a larger proportion than I observed at the other, parallel conferences. The Netherlands, Italy, and Austria were well represented (in that order), and a few participants came from Japan and several speakers from the US. The laser meetings were "isolated" from the other conferences inasmuch as they were not held in the city, but at a nearby resort and conference center at Igls. The isolation seems to have intensified interactions among the experts, but it made it more difficult for participants at the other conferences to attend in their "free" time.

The conference material was well organized into the following sessions:

- High-power lasers
- High-power laser optics
- High-power laser beam diagnostics
- Physics of laser material processing
- Laser material processing systems
- Laser safety

Although the majority of talks focused on technology and engineering, there were quite a few which were concerned with the experimental foundations of laser physics. I will give a few examples.

Most of the talks in the session on high-power lasers were about CO_2 lasers. Radiofrequency excitation was given much attention. TEA-lasers seem also to be a popular topic. Growing interest was expressed in CO lasers, in a range from 10 watts to several kilowatts. High-power, solid-state lasers (Nd-doped systems) are also making their way into industrial applications. In an invited paper, K.L. Kompa (Max Planck Institute for Quantum-optics, Garching, West Germany) discussed the state of the art and reliability of excimer laser sources for high-power technology.

In the next session, the talk by R. Protz (Messerschmidt-Bölkow-Blohm GmbH, Ottobrun, West Germany) seemed to me the most exciting: it discussed the technology of active optics, including wavefront correction devices. Clearly, the expertise behind this presentation did not come solely from industrial applications.

P.D. Perlo (Fiat Research Center, Milan, Italy) gave a very interesting presentation on the experimental characterization and computation of the propagation of multikilowatt laser beams from a CO_2 laser source. Actually, the talk was split into two parts, given in different sessions: first, the method of calculation, and second, the experimental study.

The complete texts of the talks are now available, and colleagues in North America may order the proceedings from SPIE, PO Box 10, Bellingham, Washington 98227-0010. Reference should be made to the "Innsbruck Conference Proceedings, #650," and a purchase order (or payment) must accompany the request. The price is $57, but SPIE members can obtain it for $44.

Paul Roman
7/21/86

A NEW INTERNATIONAL SERIES ON OPTOELECTRONICS

The international publishing house, D. Reidel Publishing Co. (Dordrecht, Holland), in cooperation with KTK Scientific Publishers (Tokyo, Japan), is launching a new book series, "Advances in Optoelectronics." Currently, representatives of Reidel are haunting European conferences and are aggressively recruiting contributions from eminent authors.

The aim of the series is to present comprehensive monographs, as well as edited collection volumes, which answer the rapidly increasing needs of scientists and technologists in the field. Some volumes will be geared for use in classrooms; others will be more specialized. Presently envisaged subjects are as follows:

- Optical communications (fibers, integrated circuits, devices, communication systems)
- Optical information processing (optoelectronic memories, recording, computing)
- Imaging techniques (holography, three-dimensional imaging, image analysis, imaging devices)
- Physical and chemical background studies (optical properties of solids, fiber materials, optoelectronic energy conversion)

The first two volumes (one on optical fibers, materials, and fabrication, the other on liquid crystal displays) came off the press in August 1986.

Publishing proposals are solicited and should be addressed to R. Cooper, D. Reidel Publishing Co., P. O. Box 17, 3300AA Dordrecht, The Netherlands. Information on publications in the series can be obtained from D. Middleton, D. Reidel Publishing Co., Promotion Department, P.O. Box 989, 3300AA Dordrecht, The Netherlands.

Paul Roman
7/21/86

CERAMICS RESEARCH AT LIMOGES, FRANCE

A research center for the study of ceramic materials has developed over the past 15 years in Limoges, France. It is composed of two academic institutions. The first, the Faculty of Science (UER des Sciences, Université de Limoges), specializes in "new ceramics studies" supported by funds from the Centre

National de la Recherche Scientifique (CNRS). Initially, the staff at the university had the status of being only associated with the CNRS, but now they have the full status of a CNRS research group (number LA 320). Alongside the university are the buildings of the second institution, the École Nationale Supérieure de Céramique Industrièle (ENSCI), which moved from Sèvres, a suburb of Paris, about 8 years ago. The ancient "École de Sèvres," which was situated on a small site in Sèvres, was obliged to relocate both because of space considerations and the French government's deliberate policy of decentralization from Paris.

The university offers in ceramics and surface treatments a DEA (Diplome d'Études Avancées) which requires 6 years of study and is equivalent to a Master's degree. It also offers a Batchelor's degree (called a "second cycle of studies," a 4-year program) in sintered materials. A comparable qualification also requiring 4 years of study is awarded in engineering at ENSCI.

The CNRS research group LA 320 is located at both the university and ENSCI. It consists of four research teams:

1. Nitride Ceramics (Director, M. Billy). This is the original team associated with the CNRS; M. Billy is also the senior director for the CNRS studies.
2. Thermodynamics and Plasma (Director, P. Fauchais). The work here concerns the synthesis and thermophysical properties of plasma-projected deposits. Further work involves chemical vapor deposition (CVD) assisted by plasma or laser.
3. Ceramic Materials (Director, P. Boch). This team, located at ENSCI, is concerned with the mechanical and electrical properties of oxide ceramics.
4. Structure and Properties (Director, B. Frit). This team's work is in crystal chemistry and crystal physics of crystals having potentially useful electrical properties.

This "new ceramics" research group is highly productive: during the period 1984-1986, they published 150 articles and disclosed 6 patents as well as completing 11 doctoral and 15 master's theses. During the same period, eight congresses or workshops were organized at Limoges and some 23 visiting professors from 11 different countries have stayed at the university for lengths of time ranging from 1 week to 1 year.

The group has had many research contracts with French industry, 28 in total, including those with Aluminum-Pechiney Turbormeca, Eléctricité de France, "Aérospaciale," Société Européene de Propulsion, Renault, Phone-Poulenc, and Union Porcelainière du Limousin. Governmental agencies providing contracts include the Ministére de la Recherche et de la Technologie (MRT), Direction des Recherches Études et Techniques (DRET), Agence Nationale pour la Valorisation de la Recherche (ANVAR), and Communauté Économique Européene (CEE). These research grants attain a total value of several million dollars; however, many grants are for specific tasks and may not permit much flexibility in ideas.

The range of equipment available to the group is most impressive. It includes equipment for all aspects of sintering (hot pressing, vacuum, isostatic), thermal analyses of all types, installations of plasma furnaces, and CVD with laser for surface treatments. They also have a complete range of x-ray diffraction equipment, both for single crystal and for powders. There is a fully equipped electron-optical facility and a wide range of chemical spectroscopy (infrared, Raman, nuclear magnetic resonance). The neutron diffraction studies are carried out at the Centre Énergie Nucléaire Grenoble (CENG) and also at the Institut Langevin Laue (ILL), Grenoble.

The laboratories at ENSCI are fully and completely equipped for undergraduates to undertake all aspects of traditional ceramic handling and preparation.

An interesting example of the quality of research being conducted by the group is an investigation by Professor Frit's Structures and Properties team. They are studying the relationship between crystal structure and electrical properties, particularly of a series of anionic conductors and piezoelectric ceramics based on the fluorite and comparable structures (tysonite). The positions of the excess anions in the structure have been determined by diffraction studies, and hence an understanding of the diffusion paths of the fluorine ion within the crystal structure. The manner in which the excess anions are accommodated in the structure is shown to be either by particular cluster arrangements (cubo-octahedral, such as M_6X_{37}), by monodimensional clusters, or by the vernier effect where the anions pack more densely in one direction.

The team is examining the following series of compounds:

- $Zr(F,O)_{2+x}$
- $Pb_{1-x}M_xF_{2+2x}$ with M=Zr, U, Th, In
- $Bi_{1-(x+y)}L_xTe_yO_{(3+y)/2}$ where L=lanthanide
- Bi_2O_3 - PbO -PbF_2 system
- $Bi_{3-x}N_xSbO_7$ with N=La, Nd, Sm, Gd, Eu
- $PbBiQSbO_7$ with Q=Zr, Ti and Sn

Other studies by this research team include an examination of the crystal chemistry and crystal physics of cordierite $Mg_2Al_4Si_5O_{18}$ and also of structures related to the fluorozirconate glasses of the BaF_2-ZrF_4 system.

Much can be expected of the LA 320 CNRS group of ceramics research laboratories. I will follow their progress and report on their work as appropriate.

Louis Cartz
7/24/86

THE BRITISH NATIONAL REMOTE SENSING CENTER

The National Remote Sensing Center (NRSC), founded in 1980, is located at the Royal Aircraft Establishment (RAE) in Farnborough, Hampshire. However, it is only within the last 6 months that NRSC has been able to move into its own facility, outside the fence from RAE. This new location will mean that visitors to the center will find it much easier to make appointments and enter the center.

The NRSC is jointly funded by the Department of Trade and Industry; The Overseas Development Administration; The Department of the Environment; The Ministry of Agriculture, Fisheries and Food; The Scottish Development Department; and The Royal Society. Generally speaking, NRSC is responsible for supplying remote sensing data and imagery; providing facilities for research into and development of image processing, analysis, and interpretive techniques; acting as a focal point for the development of remote sensing techniques and their applications; and providing education and training facilities in remote sensing. Within the center there are seven working groups which cover different areas of remote sensing: coastal processes, oceanography and marine applications, land applications, information handling techniques, education and training, hydrology and water resources, and geological applications. In practice, more than one of these areas is covered by a single individual since the total professional staff at the NRSC is less than 15 at this time. The center is primarily an operational facility, and not directly involved with research to develop algorithms for various purposes. The algorithms used by NRSC are developed by other people working at universities or research institutions.

One area that NRSC is emphasizing at this time is education. Both young people and possible users are targeted for this effort. Portable image analysis gear is taken to school groups and other interested audiences on a regular basis. In addition, the center has a permanent team of application scientists, who work with a mobile exhibition facility fondly called "The Roadshow" by the locals. It is designed to be driven to the audience to demonstrate what can be done with remote sensing; the intent is to increase interest and understanding on the part of both specific industries and the public at large.

Up to this time most of the work done at NRSC has been done with data from meteorological satellites and the Landsat series. In addition, there has been some work using data taken from the Seasat satellite. Capitalizing on this experience, the center is gearing up to be a processing center for the ERS-1 satellite, which will be launched within the next couple of years. ERS-1 will have active sensors aboard, and the data they provide will require a great deal of analysis capability.

In addition, NRSC is now the British distributor for SPOT images and will be involved with the analysis of SPOT data. On 9 June 1986, Mr. Roy Gibson, Director General of the British National Space Center and Dr. Gerard Brachet, President of SPOT Image, Paris, France), signed a contract by which NRSC will act as exclusive distributor in the UK for SPOT data (see *ESN* 40-8:264-265 [1986]).

Jerome Williams
7/21/86

THE HOOKE INSTITUTE FOR ATMOSPHERIC RESEARCH

The Hooke Institute for Atmospheric Research was founded by a small group of people who moved to Oxford in 1984 from the Department of Applied Mathematics and Theoretical Physics at Cambridge University. The group is funded from three separate sources: The Atmospheric Research Department of Oxford University (one staff member), The UK Meteorological Office (three staff members), and the National Environmental Research Council (one staff member). The institute also receives a small grant from the US Office of Naval Research to help with the publication and distribution of the informal journal entitled *Ocean Modeling*.

The institute's major, if not sole, activity is in the general area of atmospheric and oceanic circulation modeling.

Hooke Institute researchers continue to be active in the development of circulation models of the equatorial ocean (as part of the TOGA project), the Norwegian and Greenland Seas, the North Atlantic Ocean, and the Antarctic Ocean and Weddell Sea. Their plans apparently are to increase their activities by attempting to use satellite data in some of the modeling efforts. In particular, they are using simulated satellite altimeter data to obtain sea-surface slope values to examine the possibility of using this type of data in future numerical models. There is also a group from the Meteorological Office involved in satellite image interpretation. At present there is no laboratory work of a physical nature going on at the Institute.

Although it is relatively new the Hooke Institute has already developed a reputation as being one of the strongest ocean and atmospheric modeling groups in Europe. This is no doubt primarily due to the energy and expertise of the former director, Adrian Gill. It remains to be seen whether Hooke Institute's progress will continue without the dynamic presence of Gill.

Jerome Williams
7/10/86

VISIT TO THE NERC RESEARCH VESSELS BASE

The National Environment Research Council (NERC) is the British research organization with responsibility for research in the physical and biological sciences relating to the natural environment. Consequently, it is the government unit primarily concerned with oceanography.

The objectives of NERC, paraphrased from the Royal Charter, are:

1. To encourage and support research in the earth, marine, atmospheric, terrestrial, and fresh water sciences.
2. To provide advice and disseminate knowledge in these subjects.
3. To support the education and training of qualified manpower in these subjects.

NERC is financed partially by a grant-in-aid from Parliament (received through the Department of Education and Science) and partially by commissioned research from government departments and other agencies. In the most recent year, NERC's net expenditure was £90 million (about $135 million) of which £65 million were obtained from the science budget and £25 million from commissioned research.

The facility at Barry, renamed in 1978 as the Research Vessel Services (RVS), provides 1000 feet of deep-water dockage with office and laboratory complexes on an adjoining site. RVS not only supports the research vessels but also provides and maintains the extensive pool of scientific equipment necessary for effective marine research. RVS is also responsible for updating this pool of equipment by purchasing new pieces of gear as they become necessary and as funds permit.

I was impressed with the size and scope of the complex both by the large amounts of diverse stored but immediately available equipment and the maintenance and calibration facilities. There are about 70 professionals employed at Barry with current knowledge of both the standard marine scientific equipment and the more specialized pieces of gear. Many of the staff receive periodic training from the equipment manufacturers in maintenance and repair procedures.

NERC supports four major research vessels: the Charles Darwin, Discovery, Challenger, and Frederick Russell.

The Royal Research Ship (RRS, a title reserved for NERC vessels) Charles Darwin was ordered by NERC in 1982 and as such is the newest in the UK oceanographic fleet. The Darwin is about 69 meters long, has a 14-meter beam, a draft of about 5 meters, and a displacement of about 2500 metric tons. It carries a crew of 21 and has spaces for 18 scientists.

RRS Discovery, built in 1962, is the largest of NERC's research fleet. It has laboratory and work space exceeding 3000 square feet, and accommodations for 20 scientists. Discovery is about 80 meters long, has a beam of 14 meters, a draft of about 5 meters, and displaces about 3100 tons.

Somewhat smaller than the Darwin and the Discovery is RRS Challenger, displacing about 1500 tons with a length overall of about 55 meters, a beam of about 11 meters, and a draft of 4 meters. Spaces are available for a crew of 25 and 11 scientists.

The last of the fleet is the RRS Frederick Russell. She has a length overall of 44 meters, a beam of about 9½ meters, a draft of 4 meters, and a displacement of less than 800 tons. RRS Russell carries a crew of 15 and has facilities for 8 scientists.

Due to their relative sizes, RRS Charles Darwin and RRS Discovery are used on worldwide cruises, whereas RRS Challenger and RRS Frederick Russell usually work in the northeast Atlantic or in the European shelf seas. All the vessels are operated as general purpose oceanographic

research platforms, but they are made as flexible as possible with respect to specific task capability. These ships can be extensively re-equipped and reconfigured during any cruise period in order to undertake widely differing scientific tasks. Shipping of major items of equipment worldwide and installing these items aboard ship is not an unusual procedure for cruises involving either Darwin or Discovery.

One interesting feature of RRS Charles Darwin is that her decks are fitted with an extensive matrix of pocketed sockets. Standard interfacing plates can be used for equipment mounting so that prefitted equipment can be installed aboard very quickly without resorting to welding or deck drilling. Similar systems are used in the laboratory spaces, both on the deck and on bench tops.

One of the more popular systems available to NERC vessels is the Geological Long Range Inclined Asdic (Gloria), the highly successful long-range, towed, side-scan sonar system developed by the Institute of Oceanographic Sciences and built by Marconi Underwater Systems, Ltd. Its range of up to 30 km on both sides of the survey track in deep water, adaptability, and ease of operation make it unique as a tool for swift reconnaissance surveys of the ocean floor. It is presently engaged in work for the US Geological Survey as part of a 6-year agreement to survey the 5 million square miles of the US exclusive economic zone (EEZ).

NERC's four ships are available for use by American scientists if they can work into the vessel schedules. Interested scientists should contact: The Services Chartering Manager, Research Vessels Base, No. 1 Dock, Barry, Southglamorgan CF6 6UZ, Wales, UK.

Jerome Williams
7/16/86

AN INTERNATIONAL CONFERENCE ON VECTOR AND PARALLEL COMPUTING

An International Conference on Vector and Parallel Computing was held from 2 through 6 June in Loen, Norway. The conference was organized and hosted by the Christian Michelsen Institute (CMI) of Bergen, Norway, and SIAM/SIAG. Approximately 280 people from 22 countries attended. Norway was represented with the largest number of participants, with the US, UK, Sweden, France, the Netherlands, and West Germany also providing large contingents.

The conference consisted of 23 invited papers, 47 contributed papers, 26 contributed posters, and 3 workshops on industrial problems. The invited papers will be published in the January 1987 issue of *Parallel Computing*.

The conference covered a wide range of topics relating to both vector and parallel processing. By far, the topic of major interest and discussion was parallel computing on multiprocessor systems. A large number of the presentations were related to the discussion of parallel algorithms for solving various matrix problems, dense and sparse linear systems of equations, and partial differential equations. Many of these talks included real experiences with programing on some of the multiprocessor computers that have recently become widely available in the commercial market. Computers of this type represented at the conference were the Intel IPSC, the Alliant FX8, the Sequent Balance series, the Floating Point Systems T series, the Flexible Computing Systems FLEX/32, the ICL DAP, and the CRAY XMP.

Conclusion

Although the Europeans are not large manufacturers of high-speed scientific processors, they are actively engaged in the development of algorithms and applications for these machines. The current interest in both the US and Europe from a research standpoint is parallel processing on machines with large numbers of processors. A number of these machines have recently become commercially available, and both the Americans and Europeans are actively testing algorithms and applications on them. For the most part, computers with a large number of CPU's belong in the category of research and development because they cannot yet achieve the speeds and production loads that the high-speed vector machines are capable of supporting. Additionally, transportability of code between parallel machines is lacking (several of the presentations at the conference addressed this subject). With respect to scientific computing, vector pipeline processing is still king, but the parallel processors are coming. It is almost certain that large scientific processors of the future will combine both architectures. This is the direction many manufacturers are taking today.

For further information about the conference, contact Bengt Aspvall, Christian Michelsen Institute, Fantoffvegen 38, N-5036 FANTOFT, Bergen, Norway. Phone (47-5)-284410 (international).

CDR Theron C. Bone, USNR-R
Boeing Aerospace
7/16/86

SAFRAN--AN EXAMPLE OF FRENCH DEVELOPMENT IN ARTIFICIAL INTELLIGENCE

The French Aiding Systems for Formalizing Rules for Aero-Naval tactics (SAFRAN) is the first element of a French research effort to apply artificial intelligence (AI) technology to real-time decision-aiding for an isolated surface AAW combatant faced with airborne attack. SAFRAN will provide a testbed for designing and testing rule structures for dealing with scenarios. While I do not know how general the SAFRAN example is with regard to French application of AI, it does at least provide one reference point as to how and where this kind of research may be accomplished. On the whole, SAFRAN appears to be well-conceived and bounded so as not to overextend expectations for AI. At the same time, it appears to deal systematically with some of the pitfalls typical of attempts to apply AI to real-world problems.

SAFRAN is interesting for several reasons. First, its purpose is to become a tool for the development of higher level systems. Although it is an expert system itself and is currently being directed toward a specific application, it (or a descendent) is intended to become part of an infrastructure for developing a range of higher level decision-aiding systems. Second, despite the fact of its "infrastructure" status, it is being developed from the ground up to handle real-world data (although, perhaps, not at real-world rates). Third, the user model represented by the rules, although apparently not particularly motivated by concepts from cognitive science, appears to have a usable level of generality beyond a single expert.

Fourth is the realistic level of expectation and tasking that the working team seems to hold for the technology. The clearest evidence of this is the care with which the project team has delimited the decision-making tasks to be supported and, further, those parts to be accomplished with computer assistance. These boundaries, plus the evidence of progress to date, indicate a good match between project goals and level of effort assigned. Other indications suggest knowledgeable understanding of technical issues concerning some approaches to application of AI technology; for example, this group does not accept the claims of the productivity gains to be achieved from general AI system-building shells such as KEE, ART, and LISPCRAFT but rather is following an approach of using class-specific shells for this purpose.

SAFRAN is essentially a scenario generator coupled to an intelligent track interpreter. It comprises (1) a scenario generator which can use either recorded time-stamped exercise data or edited hypothetical data, (2) a knowledge base of rules for interpreting the data streams from the scenario generator, and (3) an inference engine which applies the rules to the incoming data stream in near real time. There are also various utilities such as editors for creating and modifying both the rule base and the track database, an explanation facility, and a status inspection facility.

The SAFRAN tool is specifically shaped for building decision aids for the Cassard-class AAW corvette, the first of which is due to begin sea trials in about 3 months. The Cassard, which is in the 5000-ton class, has seven major weapon systems: three missile, one gun, one jammer, and two chaff. Six of these weapon systems are targeted for integration into a decision-aiding system which is expected to be installed in the Cassard-class ships in 2 years at the earliest. (The seventh system, the longest-range missile, is currently not included in order to focus the integration effort, at least initially, on the qualitatively different close-in engagement scenarios.)

SAFRAN is currently being built by the Center for Naval Programing (CPM--Centre de Programmation Marine). The system is currently implemented in LISP running on an LMI Lambda 2 which has 2 MB of main random access memory. The rule base currently contains about 60 rules, and is projected to grow to about 200.

CDR Douglas G Hoeker, USNR-R
Westinghouse Electric Corporation
7/24/86

EUROPEAN PROGRESS TOWARD A NUCLEAR FUSION REACTOR

In the preface of the JET Joint Undertaking 1985 Annual Report, Professor J. Horowitz, Chairman of the JET Council, said that the Joint European Torus (JET) has achieved encouraging scientific results. "In terms of plasma density, temperature and confinement, JET has already reached a point where each of these three parameters is within a factor of three of those needed for a reactor."

The results achieved during 1985 have confirmed JET as a world-leading nuclear fusion experiment. Using the first of the additional heating systems--radio frequency heating--temperatures of over 50 M°C were reached. This heating system also enabled a record 6 MW of power with 15 MJ of energy to be coupled to the plasma. The JET scientists expect

to achieve considerably higher temperatures during 1986 by using the first neutral beam heating system, which was fully installed by the end of 1985.

Other achievements include reaching a world record plasma current of 5 MA (which marginally exceeds the design specifications) and holding that current for 1 second. Also, improvements in operating procedures and reliability during 1985 resulted in the production of over twice as many experimental pulses as in 1984.

Further information is available from JET Joint Undertaking, Abingdon, Oxfordshire OX14 3EA, England (Attn: J.H.C. Naple); phone 02-352-8822, ext. 3293.

C.J. Fox
7/16/86

A MULTINATIONAL BIBLIOGRAPHY OF EDUCATION

The International Bulletin of Bibliography on Education is a potentially valuable resource for educational researchers and theoreticians. Established in 1982 with the help of UNESCO, The Spanish Ministry of Education and Science, and the International Bureau of Education (Geneva), the Bulletin summarizes and classifies educational literature of 42 countries across 6 languages (see Table 1). The Bulletin's scope, which is published quarterly and summarized in an end-of-year annual edition, is impressive. All books and 167 journals concerned with educational issues are surveyed across the 42 participating countries. Information is provided by the National Libraries of the "starred" countries of Table 1, and by various universities and bibliographic institutes of countries whose national libraries do not participate in the endeavor.

Each book summarized in the Bulletin contains the name of the author(s) or editor(s), the book's title, publisher, city and date of publication, number of pages, and price. The Universal Decimal Classification system is used to categorize books by subject class. The classification system provides information regarding the major substantive thrust of the work, along with codes that indicate possible cognate areas. In addition, the table of contents is listed for each book cited along with names of contributing authors in the case of edited volumes. This inclusion provides an extremely useful indication of the kinds of issues that are likely to be addressed in the work.

Information about the Bulletin--its history and utilization--is provided in English, French, and Spanish. Both automated and manual bibliographic search procedures are outlined, as are instructions for obtaining special assistance from the project's team in the case of especially difficult bibliographic problems. Book titles, contents, etc. are given in the original language of the publication. Costs of the publication appear reasonable. In 1985, for example, the annual issue consisting of the year's bibliographic entries on the books and journals, and an alphabetical list of authors, cost $85. Information and order forms may be obtained from the following address: Proyecto B.I.B.E, Apartado 52, San Lorenzo del Escorial, Madrid, Spain.

Table 1

National Bibliographies Consulted in the Preparation of the Bulletin

Language	Number of Specialized Publishers	Countries
English	2,411	Australia, Canada*, India, Irish Republic, Israel*, Netherlands*, New Zealand*, Philippines*, South Africa, Sweden*, United Kingdom, USA*
Spanish	855	Argentina*, Bolivia, Colombia*, Costa Rica, Cuba*, Chile*, Ecuador, El Salvador*, Guatemala*, Honduras*, Mexico, Nicaragua, Panama*, Paraguay, Peru*, Puerto Rico, Republica Dominicana, Spain, Uruguay, Venezuela.
French	487	Belgium*, Canada*, France*, Switzerland*.
German	510	Austria*, Federal Republic of Germany*, German Democratic Republic, Switzerland*.
Italian	360	Italy, Switzerland*.
Portuguese	265	Brazil*, Portugal*.

William D. Crano
7/18/86

ONRL COSPONSORED CONFERENCE

ONR, London, can nominate two registration-free participants in the conferences it supports. Readers who are interested in attending a conference should write to the Scientific Director, ONRL, Box 39, FPO New York 09510.

Domain Decomposition Methods For Partial Differential Equations, Rocquencourt, France, 5-7 January 1987.

JUNE MAS BULLETIN

The following *Military Applications Summary (MAS) Bulletin* was published by the ONR, London, Military Applications Division during June. The *MAS Bulletin* is an account of accomplishments in European naval research, development, test, and evaluation. Its distribution is limited to offices with the US Department of Defense. DoD organizations should request copies of the *Bulletins*, by number, from ONR, London.

MASB Number	Title
40-86	Second Quarterly Index 1986

ONRL REPORTS

To request reports, indicate the report number on the self-addressed mailer and return it to ONR, London.

R-3-86 *Welding Science and Technology in Europe: A Survey and Assessment*, by Kenneth D. Challenger. Welding research is organized and coordinated differently within each country, but the International Institute of Welding serves to coordinate the results on an international scale. The UK, West Germany, and Scandinavia are leading the technological progress in Western Europe, but Eastern Europe places more emphasis on welding research than does the West. In all of Europe the research tends to be applied rather than basic. This report includes a list of key people.

R-4-86 *Materials Science in Europe: A Summary Report*, by Kenneth D. Challenger. This report covers highlights of European research in welding science and technology, composite materials, fracture mechanics, ceramics, and other specialized topics.

R-5-86 *Aerodynamics Research and Development at the Royal Aircraft Establishment (RAE) Farnborough in the UK*, by CAPT L. Laddie Coburn, USN. This report is a survey of the organization and division of the functions of the RAE research and development. It includes a summary that compares the UK MoD research establishments with the US Navy laboratories.

C-5-86 *Optics '86: Four Western European Countries Review Recent Achievements*, by Paul Roman. The conference in The Hague covered a very broad field of topics, including optoelectronics. This review highlights presentations on nonlinear optics, optical data storage and optical computing, image processing, and novel optical materials.

C-6-86 *Life Sciences Conference "From Enzymology to Cellular Biology,"* by Claire E. Zomzely-Neurath. This report covers presentations on the topics of enzymology, enzyme engineering and biotechnology, metabolic regulation, gene expression and transcriptional signals, and replication. It includes a table showing the scientific program of the conference.

ANNIVERSARY SUPPLEMENT

1946 - - - - - 1986

A celebration of 40 years of continuous service to science and technology

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Preface

It became clear that scientific liaison was needed.

In the aftermath of World War II, the Office of Naval Research accepted national leadership in advancing scientific knowledge through basic and applied research. Scientific liaison with Europe became a natural part of this effort, and the Office of Naval Research assumed responsibility for the London Liaison Office of the wartime Office of Scientific Research and Development; this became ONRL: the London Branch Office of the US Office of Naval Research.

The destructive events of the war had not only shut down many scientific centers of Europe, but had also disrupted scientific communications. In 1946, on both sides of the Atlantic there was little information about the results of research done immediately before and during the war. Moreover, personal relationships between scientists of the opposing nations had nearly ceased.

One of ONRL's first tasks was to collect previously unreported information on scientific progress in Europe and distribute it in the United States. At the same time, ONRL scientists provided their European colleagues with news about scientific research in the United States. These activities helped reestablish the many personal and official connections that now exist between the European and American scientific communities.

As scientific activities in Europe resumed and continued to grow vigorously, it became clear that scientific liaison was needed not just as an immediate postwar measure, but also on a permanent basis. Thus, ONRL continued as the first US Government agency in Europe primarily concerned with this activity.

The scientific liaison has been maintained through 40 years of continually accelerating advances in science, and today, as before, European and Middle Eastern scientific and technical institutions look to ONRL for support to disseminate their research and to establish contact and develop cooperative research programs with US (and specifically Navy) institutions in many fields of R&D. In turn, they have opened their laboratories and universities to the US Navy R&D community as well as to other R&D visitors from the United States. That is the achievement we celebrate with this anniversary supplement.

Introduction

It is a great pleasure to introduce this 40th Anniversary supplement of *European Science Notes*. Science and technology have in this century been a cornerstone of support to the building and maintaining of a modern Navy. Navy operations span the globe, and Navy units must be prepared to successfully operate in any environment on a continuous basis for lengthy periods of time. We must also have and

maintain the technological edge required to ensure we can meet and defeat any adversary on any terms.

At times, science and technology seem remote from day-to-day fleet operations. It is, however, a fact that today's fleet systems and technology are an outgrowth of the scientific developments and breakthroughs which have been achieved over the last 10 to 20 years. It is also noteworthy that science, as supported and conducted by the Navy, has made significant contributions to the nation in a broader sense. For example, Navy development of underwater remote vehicles to support undersea operations has paid a significant national and scientific dividend with their use in the discovery of the Titantic. This technology has unlimited industrial and scientific potential.

Over the past 40 years, the Office of Naval Research Branch Office in London has followed on the World War II scientific liaison which was so critical to victory. Today we continue that effort, but new forces are coming into focus. As the complexity and cost of modern research increases, the nation and the Navy must look for ways to sustain our research efforts, but in a cost-effective manner. The Navy must consider international or bilateral joint systems development with other countries so we together can maintain our technical edge at affordable cost. In basic research, we likewise must look continually to the superb efforts of our friends and allies for new concepts, ideas, and technical advances that we can capitalize on together by cooperative research and development. As congressional actions balance the budget we must be prepared to make up the difference by working and sharing with our allies. To this end it is clear to me that the role of ONRL will become more critical and our efforts more important than at any time in the past. We have been and, I believe, will continue to be "players."

I wish to close by thanking the ONRL alumni for your contributions. Thank you for helping to get us to our 40th Anniversary. Those of us here today will make every effort to carry your work into the future. Well done!

CAPT Terry J. McCloskey, USN
Commanding Officer

As in the Past ....

My reaction to organizing an event honoring the 40th Anniversary of the Office of Naval Research at the Branch Office, London, was one of extreme caution and much reservation. To my surprise, we had nearly a 50 percent response to the nearly 200 letters sent out to those alumni of ONRL for whom we had some reasonable mailing address. The second mailing produced about the same statistics, but the number of articles, notes, and commitments to join us in London in October made me realize how close-knit an organization ONRL was and still is. In addition, I must have caused a lot of people to pause in their daily activities and evaluate their contribution to the Navy and themselves by their tour at ONRL. The replies I received clearly reflected this.

Responses from alumni of ONRL were a delight to read. Because of limited space we could not print them all, but for those who visit ONRL they will be available for your

perusal. When I read the articles included in this special supplement honoring the ONR anniversary, I suddenly realized that the 40 years that I was reading about was really a short period of time compared to the age of the cultures, buildings, and cities with which we come in contact during our tours at ONRL. For example, the City of Westminster, where I live, celebrated its 400th anniversary last year!

Like the City of Westminster, ONRL has changed, but over the short span of 40 years. Most notable is the change in communication. The advent of electronic mail, to say nothing of the personal computers (on most Liaison Scientists' desks), mini tape recorders, and the word processor have altered the mode of operation of a Liaison Scientist. Fortunately, the mission has not changed.

Bringing people together for the benefit of the Navy is my interpretation of the very formal mission you find in the offical documents. The examples that Jim Fox, our editor, so wisely chose to include in this supplement illustrate this point again and again. The scientific level of our person-to-person interaction is the pride of ONRL, but others wonder about the merit of the operation. How do you evaluate the success or failure of the ONRL operation? For the 20 to 25 alumni of ONRL who attend the meetings in London the week of 6 October 1986 this will be a question on which I seek comments.

As in the past, the focus of ONRL covers the spectrum of basic research, technology transfer, industrial technology, and hardware. The intensity of the focus changes from time to time, but the interaction between people remains. Operation of the office continues to change: it should, or it would deteriorate with time as so many fixed structures do. With personnel, funds, and space limited, the challenge now is to use other means to expand our coverage, receive increased guidance from the US, and ensure that we disseminate the information to the proper audiences in a timely manner. This is our challenge for the future. I hope to see how this challenge was met when I read the 50th Anniversary Issue of the *ESN*.

This is our challenge for the future.

David L. Venezky
Scientific Director

Voices of Experience ... 1946 - 1986

The "voices of experience" which follow are a few of the many who responded to our invitation for short articles which, we hoped, would convey both the personal and the scientifically significant aspects of ONRL's work--how the mission is fulfilled and what that fulfillment meant and still means to the people who have done the work and can see it now in perspective.

The response was enthusiastic, so enthusiastic, in fact, that I, the editor, experienced a happy embarrassment of riches. I also received an education: as a relative newcomer to ONRL, I was struck again and again by the importance of the function this office has served for so many years, by the alumni's loyalty to and extraordinary warmth of feeling for ONRL and their former colleagues, and by the professional stature so many of them achieved in the years following their London tour.

But, of course, no one needs to be told this. ONRL's sustaining liveliness and the continuing pertinence of its operation to US (and European) science is testament enough to the character of the people who have been part of it.

In The Beginning...

Albert M. Stone, Physical Sciences, 1946 - 1948

Some one once wrote (was it Julian Huxley?) that it is the fate of new ideas to begin as heresy and to end as superstition.

Certainly 1946 was a year when the London Office of ONR was an heretical idea--the notion that an overtly military organization could bridge the 5-year gap between university scientists across the Atlantic. In retrospect, this mini-Marshall Plan of reconstruction indeed generated doubts and raised eyebrows. But now, forty years later, ONRL seems to have emerged from antiquity and it seems that it will last to eternity. Superstition? Maybe.

In retrospect, this mini-marshall plan of reconstruction indeed generated doubts and raised eyebrows.

ONRL started in 1946 at the very end of World War II, with Holbrooke McNeille, a mathematician, as director and Daniel Clapp, a chemist, as deputy director. Recruited by my friend, Samuel Goudsmit, I arrived in October of that year as the first physicist in the ONR London office.

Shortly after I arrived we started the *European Science Notes (ESN)*, of which this is presumably Volume 40. At that time we were located in the Office of the Assistant Naval Attache for Research (OANAR) at the American Embassy at 20 Grosvenor Square, with a side entrance at 6 North Audley Street. Looking out from my office room across North Audley Street, I could see a most elegant dining room, lounge, and living quarters in a building whose entire facade had been torn out by a bomb during the last years of the war and, of course, nothing had been replaced at that time. It was an ugly but convincing symbol of the destruction that was in patches all over central and west London but was almost complete over the East End. Grosvenor Square itself was a mud-pit about 10 feet deep--revetted that way in order to store some of the military vehicles of General Eisenhower's Headquarters in London.

That *ESN* filled a void in the late 1940's and 1950's is self-evident. Liaison between the US and European scientists was in a slow process of restoration. The survival of *ESN* to the present, in spite of the proliferation of international meetings, travel, and exchanges, is a tribute to the capability of the ONRL staff to establish the value of in-depth scientific reporting by on-the-spot certified experts.

In the first years a great deal of effort went to shepherding American scientists to meetings with European (principally British) colleagues. Given the travel exigencies of the first couple of postwar years, this was no trivial task and constituted a fair fraction of our daily tasks. One example is Alan Waterman arriving for a visit with British government scientists, lunching at my flat, and finishing his stay at a reception by McNeille that included Lord Cherwell as a guest. Since I was an "honorary" member of the postwar Committee on Valve Development (CVD), I had entree to most of the electronic laboratories belonging to the UK Ministry of Defence as well as to their industrial contractors. These relationships--many of which persisted for decades--became valuable passports whereby I could readily

introduce our American scientists to their British counterparts.

Things were very grim in Britain in those days. The condition of the British public was more onerous than, in fact, that in the so-called conquered countries, West Germany and Occupied France. Food was extremely scarce; rationing was severe. My recollection is that the allowance was one shilling's worth of meat per week per person, one egg per week per person, and one pint of milk per day--but only for children. One of the most curiously skewed economic realities was the cigarette economy. Cigarettes replaced money all over western Europe and, indeed, to some extent in Britain itself. A substantial taxi ride in London could be paid for in shillings, with a pack of camels (worth $.09 at the time) as the tip. This actually turned out to be largesse on a world-class scale. On the Continent, cigarettes, coffee, or chocolates could get you almost anything. The mystery of what happened to the cigarettes has never been solved. No one smoked them; they were too valuable. They passed, one by one, from hand to hand until, I guess, they disintegrated into shreds of tobacco.

The mystery of what happened to the cigarettes has never been solved.

From the professional point of view we had an exceedingly difficult job to dispel the notion that we at ONRL were there as part of the military intelligence services. It was hard to get across the idea that ONR was determined to help reestablish in the Western alliance the research ability, the research infrastructure, and the equipment that had been so badly mauled during the war. It took those first 2 years to succeed in that. As the years followed, respect for, and acceptance of, the ONRL scientific liaison function grew. We all can take pride in that.

For me personally, it was a remarkable experience to be able to have contact with some of the world's leading scientists. For example, in England I lunched with Sir Neville Mott in London and Bristol and met Sir Martin Ryle at Cambridge and Professor Dirac at Oxford. Heisenberg was interned at Cambridge at that time and that meeting was a thrill to me. In Paris I met with Joliot-Curie and got a lecture from him on Marxism. In Scotland Max Born was teaching at the University of Edinburgh and spared me some of his time. In Sweden I met with Hannes Alfven and Manne Siegbahn, and in Copenhagen, had an unforgettable interview with Niels Bohr. Then there was Paul Scherrer in Zurich, Zernike in Holland, Harrie Massey in Belfast, Blackette at Manchester--and on and on.

In Paris I met Joliot-Curie and got a lecture from him on Marxism.

It is beyond my skill to convey the immense and spontaneous surge of emotion as thousands stood in the beautiful gardens on Princes Street in Edinburgh one evening in September 1947, staring up at the lofty grandeur of the great Castle, when suddenly the huge crag was brilliantly illuminated for the first time after being blacked out for 6 years.

With such experiences, I could hardly fail to become deeply internationally oriented. When I returned to the US and became Technical Assistant to the Director at the Applied Physics Laboratory (APL), Johns Hopkins University, a significant part of my job for the next two decades was to spearhead relationships with our European allies. I organized a number of trips to Britain, for example to the predecessors of the Royal Radar Establishment, to the Admiralty Surface Weapons Establishment, the Royal Aircraft Establishment, the Marconi and General Electric laboratories, the Ferranti firm, and so on.

The close personal relationships with many of the leading people I had enjoyed during my stay in London persisted and were invaluable for supplementing our efforts at APL in the development of air-defense missile systems. In

reciprocation, our British colleagues came to the US--frequently here at the APL--and on a number of occasions we criticized each other's programs effectively and constructively. Both sides profited from the interaction. I cannot help but wonder whether personal facilitation of one-on-one exchange on the part of ONRL is still as valuable in view of the extensive interactions now available through the NATO connections and through other government-to-government relationships which have been established through memoranda of understanding with our allies.

However, that was not true during those first days in London. What we were able to establish in 1946, 1947, and 1948 laid the groundwork, I fully believe, for resuscitation of European technology and science. Resuscitation would surely have occurred, but later rather than sooner, without ONR in London and the Marshall Plan. For myself it was an experience that I treasure deeply and one that has profoundly influenced my life.

We laid the groundwork, I fully believe, for resuscitation of European technology and science.

Received with Universal Warmth

Bradley F. Bennett, Commanding Officer, 1957 - 1960

I was extremely fortunate to wind up my active-duty Naval career with 3 years at ONRL followed by 5 years at Naval Research Laboratory. The most impressive feature of the ONRL experience was the almost universal warmth with which ONRL people were received. An event which I have always cherished in this regard was my introduction to Nils Bohr. This great man of modern physics acknowledged the introduction by thanking me for the great contributions ONRL had made to science in Denmark and in all Europe. I believe this stemmed in large part from an action initiated by C.E. (Gene) Sunderlin, ONRL's third Scientific Director. Gene and his scientific staff worked very hard to persuade colleagues at home to give their scientific publications of the war years to fill the gaps in the university libraries of Europe.

This great man of modern physics acknowledged the introduction by thanking me for the great contributions ONRL had made to science in Denmark and in all Europe.

The other key feature of ONRL was that we were recognized as collaborators. "ONRL people are not blotters," was the way one leading European scientist expressed it.

One other incident may be of interest. Theoretical physicist Joseph Jauch was with us in 1959, and after a visit to Organisation Européenne pour le Recherche Nucléaire (CERN) he criticized a piece of theoretical work he found there. So many US physicists visit and work at CERN that Jauch's article came to the attention of Director-General Bakker. When I visited CERN not long after that, Bakker came storming in to say that if ONRL visitors were going to criticize the work at CERN they would not be welcome. To which I replied that if we could not comment freely there would not be much point in visiting. He did accept that, and wound up later in our conversation praising ONRL as an activity which, although sponsored by a military organization, carried out its mission in a very nonmilitary manner. Jauch later joined the faculty at the Université de Genève and collaborated extensively with CERN.

A Great Deal Has Happened

Eugene P. Cooper, Physical Sciences, 1964 - 1965

A great deal has happened in the 22 years since I served in London, not only to me, but to the whole Navy and, in particular, to naval research. Among all the great disturbances, there are few stabilizing elements. One of these is the Office of Naval Research Branch Office, London, and I'm happy to have served this steady light. For me, 1964-1965 was a bit like a sabbatical and was an opportunity for self-reevaluation; it led to my desire to devote myself to directing research and away from my former role of Navy Laboratory technical direction. I was the Technical Director of the Naval Radiological Defense Laboratory (NRDL) in 1964. By an unusual arrangement, NRDL and the Office of Naval Research agreed to let me perform in all respects as a liaison scientist in London while retaining the NRDL technical directorship. This was possible because of the able assistance of my deputy, the late Edward R. Tompkins, who, incidently, was an ONRL alumnus at that time. NRDL was concerned with all radiation effects of nuclear weapons and therefore with nuclear physics, thermal effects, radio- and radiation chemistry, radiobiology, and the engineering problems of decontamination and radiation shielding. Among these subject areas there was plenty of room for operation of a liaison scientist.

The unusual nature of my appointment led to unusual liaison activities. Instead of concentrating mostly on university liaison, which was the mode for many of my colleagues, my liaison work was split between universities and government laboratories. In the UK that included the Atomic Energy Research Establishment, the Atomic Weapons Research Establishment, the Admiralty Research Laboratory, the Naval Construction Research Establishment, and the Director General (ships) offices at Bath. In other countries it included the Civil Defense Organizations of Norway and Sweden, the National Atomic Energy Laboratories of Denmark, the Defense Research Institute of Sweden, the Ministry of Defense (West Germany) at Bonn, and several other government R&D organizations. This whole experience was highly informative and enlightening to me. I hope my reporting of it was equally valuable to the readers of *ESN*.

My experience as a liaison scientist rekindled my research interests from previous years.

My experience as a liaison scientist rekindled my research interests from previous years, such as in torpedo hydrodynamics, guidance and control, and propulsion; aircraft fire control; and solid-state physics. These all come together for me in my present position as Program Director for Research at the Naval Ocean Systems Center (NOSC), whose research program also includes aspects of nuclear physics and chemistry. In addition, my association with the biological research at NRDL had provided a good basis for my interaction with the biologically oriented scientists at ONRL, and this, in turn, developed into a real appreciation for the work we are currently conducting at NOSC on capabilities of marine mammals.

The activities of ONRL have played a hand in many of the independent research (IR) program developments at NOSC, not only because of ONRL's effect on my career, but also because of its continuing liaison activities with European science. We really appreciate the window to science that ONRL provides. We have very active interchanges through the liaison scientists, such as in my case, for example, through Dr. Paul Roman. Many of the leads our scientists get to further their research come from these interchanges.

What Kind of Science is That?

H. Wallace Sinaiko, Psychological Sciences, 1967 - 1968

When people ask about my year at ONR London, and many people do, I can sum it up in four words: "Afterwards it's all downhill." I served, in 1967-1968, as the tenth psychologist appointed to ONRL since the first incumbent's tour in 1951. It was a time to remember. Here, 19 years later, are some reasons and recollections.

1967-1968 was a low point in US national prestige abroad--the war in Vietnam, student protests, and the like. But none of that diminished the personal or professional hospitality I experienced. European hosts--in the East and in the West--were eager to talk about their work and mine, and politics never intruded. The support of the US Navy for what I was doing made no apparent difference. In fact, ONRL's reputation preceded me by many years in some places, and I was well received because of it.

I was repeatedly struck with how sophisticated European physchologists were in their knowledge of US research.

The year provided a humbling experience, too. I was repeatedly struck with how sophisticated European psychologists were in their knowledge of US research. They were familiar with our literature, they read the journals (almost always in what was a second language for them), and they kept in touch. Related to this point was the absence of any problem due to my own monolingualism: accented English was certainly the international language of science.

One of the best things about serving in ONRL was that we had nothing but our interest to bestow on the people we visited--no contracts to dangle, no travel grants. I went to Barcelona and Sophia and Palermo and Nottingham only because of the psychology that was going on in those places and because it was important to learn about it. It was clear that my hosts knew they didn't have to give me their time because I brought no prospects of support. And that certainly accounted for much of the candor I found.

Here are some highlights of one man's year in the London office: having lively discussions with Italian ergonomics professors; observing demonstrations in a Dutch laboratory of elegant experiments on the control dynamics of very large merchant ships; lecturing in the dark (literally, because of a power failure) to the Serbo-Croation Psychological Society; participating with 299 people from Eastern Europe in a 300-person international congress on applied ergonomics; talking with a Roumanian psychologist about her prolific work in psycholinguistics; arguing the merits of a national survey research program in Israel; talking about poetry and factor analysis with Spain's only Thurstontrained professor; being announced to an English lord mayor by his Beefeater-garbed aide; being invited to toast the health of a British society (which I did in verse supplied by the president of the counterpart American society); observing experiments on animal aggression in a Finnish laboratory; learning first-hand of an exciting program in Wales that dealt with the design of facilities for the aged and the disabled; hearing a great deal of debate, throughout the year, on the measurement of mental workload; and listening to a Bulgarian industrial psychologist's theories of color in the work place and his citation of Marx and Goethe as primary sources.

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I want to end with an account of a misunderstanding that I really hated to clear up. It occurred on a cold day in early December in Bratislava. Two local psychologists met

me at the hotel for what became a very wet and pleasant afternoon and evening. But at the start they had a question: "Under your signature on the ONRL letter it reads, 'Liaison Scientist.' We looked up 'liaison' in our Slovak-English dictionary, and the word means 'an illicit relationship between a man and a woman.' What kind of science is that?" Too bad I had to tell them there was a second definition.

"We looked up 'liaison' in our Slovak-English dictionary...."

Benefits of ONRL Service -- A Personal Note

H. J. Walker, Earth Sciences, 1968 - 1969

I had been to Europe several times (often with ONR support) prior to my ONRL service and was somewhat acquainted with the fluvial, coastal, and arctic research being done by the British, Germans, and Scandinavians. Such preconditioning helped greatly in establishing my initial contacts with the European scientific community.

During my 15 months with ONRL I visited research institutes, academic departments, and scientific laboratories and attended and participated in a number of professional meetings in many countries (see Figure 1).

The advantages gained from my ONRL days have taken several forms. They include benefits to my own research, benefits to Louisiana State University (LSU, my home university), and continuing contacts within Europe at the professional and personal levels which help enliven the international cooperation and interchange of information.

Examples of benefits include my field research in Arctic Alaska, which has included three foreign scientists (Scotland, Sweden, and Germany), two of whom I met while at ONRL. (A number of research articles, published with each of them, have appeared in several European journals.) Another major benefit accrued to LSU students in geomorphology, alluvial morphology, and coastal morphology, during the 1970's. Although my own teaching must have improved because of my European exposure, a more important benefit came from the nine visitors from Ireland, Scotland, England, Germany, and Sweden who taught for a semester or more and the many other Europeans who visited for shorter periods of time: According to what our graduates tell me, the new approaches and concepts these foreign visitors passed on have proven invaluable.

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While in London, I was fortunate enough to have established contact with members of a number of organizations including the British Association for the Advancement of Science, the Royal Geographical Society and the British Geomorphological Research Group (BGRG). My association with the BGRG has been very close for over 15 years. Because of this association, I was asked by the Japanese geomorphologists to

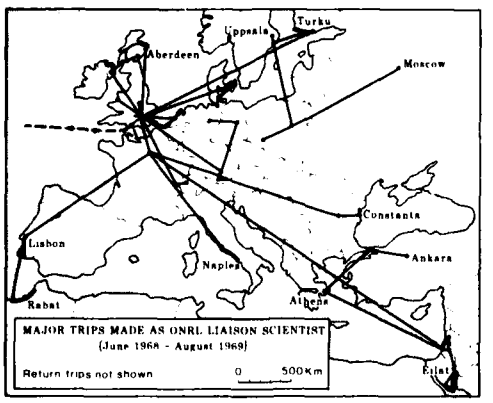

Figure 1. Major trips made as an ONRL liaison scientist.

discuss BGRG's organizational structure when the Japanese were planning on forming a geomorphological union of their own, which they did 6 years ago.

My most recent contact with the BGRG came in 1985 at Manchester, England, at the time of the First International Conference on Geomorphology, which was attended by geomorphologists from 61 countries. This conference was organized by the BGRG and had as one of its major objectives the determination of the desirability of forming an international geomorphological organization. I had the privilege of presenting the keynote address "Potentials for International Collaboration in Geomorphological Research" at the plenary session and was later elected secretary of the international organizing committee. Such involvement would have been very unlikely had it not been for the contacts I made while with ONRL.

Nevada After ONRL

Vern M. Smiley, Physical Sciences, 1977 - 1979

My 2-year term at ONRL has had a significant impact on my career and activities. One aspect of this impact resulted from the interaction with British and European scientists in my then current interest of atmospheric probing with lasers. Visits with investigators at a number of institutions in Germany, France, Italy, and the UK employing optical radar helped broaden my awareness of the myriad of available techniques and instrumentation. This aided my own research when I returned to Nevada, particularly in reference to methods for remotely measuring various gases using differential absorption backscatter, Raman, and fluorescence techniques.

Additionally, during my tenure in London, I looked at research in the electro-optic and fiber optic areas at the University of Southampton, Electro-optic Developments, Ltd. at Brentwood, Plessy's Allen Clark Research Center near Northampton, the Physics Department at Brunel University in Uxbridge, and other institutions. I had been interested in these technologies previously while employed at the Naval Electronics Laboratory where I helped initiate early efforts along those lines in addition to my main interest of laser research. I did not realize, however, that this would be of importance again in my own research as it had nothing to do with my work at the Desert Research Institute.

I did not realize that this would be of importance again in my own research.

Within 1½ years after returning from abroad, I was offered a position with the EG&G Company in Las Vegas, Nevada, to establish a fiber optics and electro-optics R&D group to work with Los Alamos National Laboratory (LANL) on nuclear weapons testing at the Nevada Test Site. The 6 years I spent on this program was a most rewarding highlight of my career both in regard to the challenging scientific work and to the personal associations with EG&G and LANL personnel. My association with ONRL had some influence on my taking this position.

Laser research has been a main thread of my research activities all of my career. I visited a large number of laser research laboratories in the UK and on the continent. A few months ago I was awarded the opportunity of returning to laser research by making a change in jobs. This new position is with ONR at the Pasadena Detachment where I am working on high-power lasers.

Another area where my experience at ONRL was very helpful was in writing skills. In the process of writing over

50 *ESN* articles and ONRL reports, I believe my writing technique improved considerably, especially during the early months of my tenure in 1977 when Jim Schulman's devastating editing pen (along with additional comments from two other editors) smoothed out my articles. As a result of reading one of my *ESN* articles on laser research, the editors of the Academic Press series, *Advances in Electronics and Electronic Physics* enticed me into writing a 100-page chapter entitled "Recent Advances in High-Power Tunable Lasers" for Volume 56, which appeared in 1981. Presently I am working with an ONRL alumnus, Roy Potter (now with SPIE) to write 1½ chapters for a book entitled *Broadband Applications of Photonics*, to be published by SPIE late in 1986.

I naturally stopped in at ONRL to discuss European research activities.

On a recent business trip for EG&G to England to visit with scientists doing research on ultrafast electro-optic deflection schemes, I naturally stopped in at ONRL to discuss European research activities with Paul Roman and James Daniel. This visit was rewarding and helped me in my search for information on current activities in optics research abroad.

In summary I can firmly state that my tenure at ONRL influenced my career development and activities since I returned from London and anticipate that this influence will continue through the years ahead.

From Finland to Arizona...Crack Detection to Sunlight Measurement

Irving Kaufman, Mathematical and Engineering Sciences, 1978 - 1980

With my background in microwave electronics, solid-state devices, ultrasonics, and a bit of optics, my ONRL assignment was to cover virtually anything related to Electrical Engineering.

During that period I visited Professor M. Luukkala.

Finland. During that period I visited Professor M. Luukkala, of the Physics Department of the University of Helsinki, who was engaged in a number of very interesting ultrasonics projects. He had also recently started an activity in a photo-acoustic method of detecting minute cracks on a surface, which he demonstrated to me. The method was to use an amplitude-modulated laser beam to heat a specimen located in a closed container. Also in this vessel was a microphone that picked up sound created by the alternate heating and cooling of air adjacent to the specimen. By slowly scanning the laser beam across the specimen, cracks were detected by noting the increase in intensity of sound as the beam crossed the crack. Because the requirement of the closed vessel was a severe limitation to employing this technique for nondestructive testing, Luukkala had found an alternative: He monitored the surface temperature radiometrically with a far-infrared detector. Though not as sensitive as the photo-acoustic method, it worked!

To Arizona. Since I returned to Arizona State University, this technique of photothermal radiometric imaging (PRI) and related techniques of nondestructive testing have been the subjects of investigations of five of my graduate students--P-T Chang, A.K. Choudhury, H-S Hsu, W-Y Huang, and D-Y Shyong.

Another graduate student, J.D. Birkeland, has used the photothermal principle to develop a system for measuring the intensity of highly concentrated sunlight, a type of measurement useful for solar-cell concentrator research.

Sponsors for various portions of this work have been the Electric Power Research Institute (EPRI), Garrett Turbine Engine Co., and Sandia National Laboratories.

One of the missions of EPRI, as a representative of much of the electric power industry, has been to develop effective methods of nondestructive evaluation (NDE). One aspect deals with methods of discovering surface cracks, both for "off-line" NDE (with the machinery diassembled) and for "on-line" NDE (while the machinery is operating). The PRI technique is a possible candidate to supplement already existing techniques.

Garrett, as a manufacturer of high-temperature turbines, needs to ensure good bonding between the metal of a turbine blade and its protective coating. Since PRI can "see" slightly below the surface, it can find such bonding faults.

After initiating our PRI work, we discovered that similar work had already been in progress in the 1960's, though without lasers (Maley and Posakony 1963, Kubiak 1968). Because of the ability to focus a laser beam into a fine spot, A.K. Choudhury found that he could readily detect cracks as small as 0.0006" in width. We found out, however, that to perform NDE of a surface that would be encountered in a power plant was not as easy as finding a crack on a smooth, clean piece of metal. Surface granularity and the presence of surface blemishes produce false responses--a type of "surface noise" that masks the crack signals. While our calculations indicated that a type of measurement possible with the modulated laser technique could eliminate a lot of this surface noise, the times required for carrying out this measurement become prohibitively long for practical NDE. Additional calculations by Shyong, however, indicated that continuous scanning with an unmodulated laser beam at reasonable speeds (~1 cm/sec) should also reveal surface cracks. While this was easily demonstrated, the problem of the surface noise remained with us. An example of the kind of output obtained from a rough steel disk with a 0.0004" surface crack (Figure 1) clearly shows that the pits in this rough surface are too great to permit identification of the crack. However, by using differential detection with two detectors aimed at slightly different locations (Figure 2), the majority of the surface noise could be removed. The

... could readily detect cracks as small as 0.0006" in width.

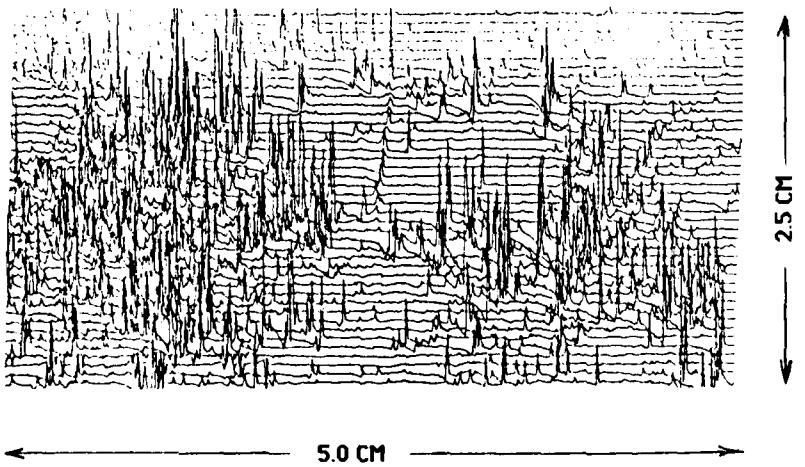

Figure 1. Single detector PRI record of a steel disk with rough surface and with a surface crack. Scanning was performed with multiple passes vertically displaced by 0.6 mm.

result is shown in Figure 3, where the crack is now clearly identified. Additional improvements should be possible by the use of image processing techniques and by rapid signal correction for local emissivity and absorptivity. Work on the latter by Huang is presently in progress. Also, while our work to date has been limited to slow, line-at-a-time scanning, we can expect that the use of array detectors, which are currently available, will permit rapid area scanning.

Since PRI depends on heating, it will find cracks even if these are slightly covered (Rosencwaig and Busse 1980, Tam 1983). We discovered, on the other hand, that open cracks can be found radiometrically without heating because the emissivity of a crack is greater than that of the surface in which it is found. We have recently used this principle to construct a map delineating a crack that was on the surface of a shaft from signals obtained while the shaft was rotating at high speed. Moreover, by storing the radiometric image of an area in a computer and subtracting this image from one obtained at a later time, any changes in the surface will become readily visible (Kaufman and Choudhury 1985).

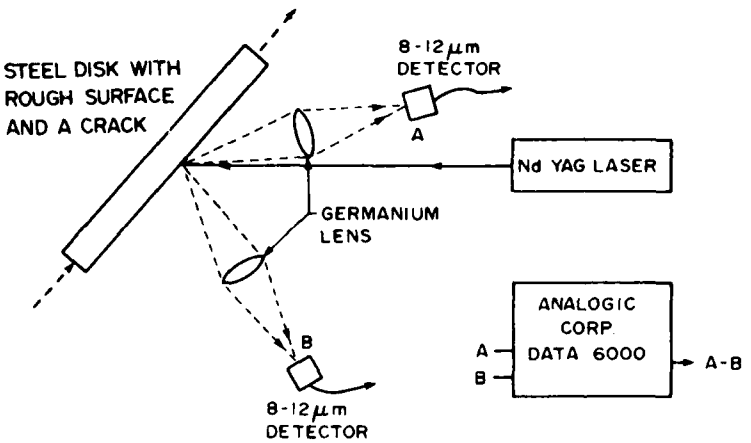

Figure 2. Two-detector arrangement.

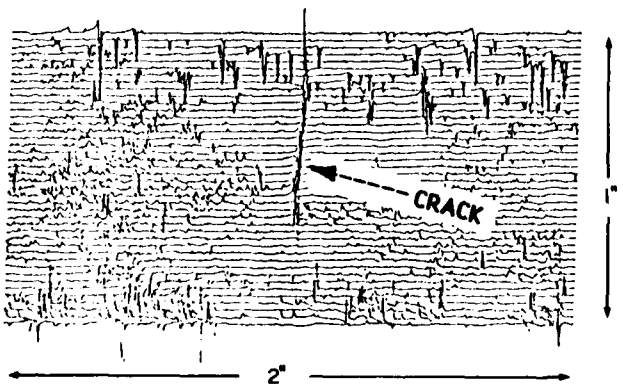

Figure 3. PRI record of the disk of Figure 1, but with differential detection.

While working on this method of on-line crack detection, Chang suggested using optical scanning to detect open cracks. In the preferred version of this method, a detector is placed to receive light only when it is reflected from one of the edges of a crack. An example is seen in Figure 4. Using oscillating mirrors to achieve two-dimensonal scanning, and with z-axis modulation of an oscilloscope by the detector signal, we have obtained images delineating cracks in reasonably rough surfaces, such as a barely visible crack of width 0.001", depth 0.002", and length 0.25" that was spark-machined on a section of turbine blade. The map seen on the oscilloscope screen for this crack is shown in Figure 5. We have also used this technique to construct maps that delineate cracks on the surface of a shaft from signals received while the shaft was rotating at high speed.

Finding bonding faults of coated turbine blades means using heat to "look" below the surface. How deep one can "look" with an amplitude modulated ("chopped") laser by monitoring surface temperature depends on the thermal conductivity of the coating and the chopping frequency f_0 (Rosencwaig 1979). Our zirconia coating of thickness up to 0.015" called for f_0 to be 1 Hz or less, therefore implying very slow scanning. Hsu was able to use this chopped laser technique to find a number of bonding faults. With simultaneous heating of a patch and two-dimensional array detection, this type of NDE could be carried out at production line speeds.

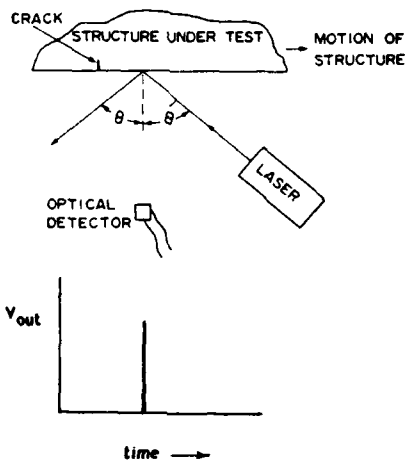

Figure 4. Optical scanning method of crack detection.

Figure 5. Oscilloscope display highlighting 0.001" crack on turbine blade.

To Solar Concentrators

That we would use the photothermal method of crack detection demonstrated to me in Finland to measure the intensity of concentrated sunlight (Birkeland et al., 1986) was indeed unexpected. But the method turned out to be quite simple. The sunlight was chopped and allowed to impinge on a black metal plate to produce a time-varying surface temperature, which was measured by an infrared radiometer. By calibrating this system with a solar cell in the range in which the cell short-circuit current is known to vary linearly with light intensity, high ratios of solar concentration could be determined. Using this technique, Birkeland found the short-circuit current of an n^+p solar cell to be linear up to a concentration of 410 suns.

Clearly, my trip to Finland turned out to be worthwhile. I am now trying to follow up on a still-current topic that I learned about on another ONRL mission. I hope to be able to report on it in the next ONRL Festschrift.

Clearly, my trip to Finland turned out to be worthwhile.

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ONRL To Today: Continuity of Experience

Herbert Solomon, Chief Scientist, 1978 - 1980

When I arrived in London in early January 1978 for a 2-year tour, I knew I would be meeting many European colleagues in statistics. This would especially be so in the UK because of location and the intellectual strength of the British school of statistics. However, I recognized that my duties and responsibilities as Chief Scientist would include much more than reporting on statistics and probability in Europe and the Middle East.

I would soon meet with my British counterparts in the Ministry of Defense and other government agencies. In addition, I would represent ONR at international science events. Two occasions, among others, stand out in my mind: serving as an official delegate as part of the American group at the 20th anniversary of the NATO Science Committee in May 1978 in Brussels, and in December of the same year, representing ONR at the Nobel Prize ceremonies in Stockholm.

These representational aspects of the position meant, of course, some study of the way science and technology are organized in countries falling within our purview. I accomplished this study through informal conversations and reading what others had to report. One vehicle for accomplishing this, in addition to visits, was the London Science Club. This group was composed of the science and cultural attaches (East and West) stationed in the UK. Relatively informal monthly meetings usually took place, and receptions were sometimes held at which information could be exchanged. I should also add that relations with the US Counselor for Scientific Affairs in London were quite cordial.

These representational aspects of the position meant, of course, study of the way science and technology are organized in the countries falling within our purview.

I have expounded a bit on these remembrances because I still find myself involved in this kind of activity. A year or so after my return to Stanford, Dr. Elliot Weinberg (a 1965-1966 ONRL alumnus), who was Director of Research in ONR headquarters when I was in London and was then serving as ONR liaison to the Naval Intelligence Command, informed me of his interest in looking into how science and technology were organized in the Soviet Union and other countries. He was also interested in how one could keep abreast of the open scientific literature in the Soviet Union and other countries.

These interests and others achieved formal recognition when the Naval Studies Board of the National Academy of

Science recommended the formation by ONR of a Navy Center for International Science and Technologies (NCIST) to be located at the Naval Postgraduate School at Monterey, California. This center has now been in operation for 3 years, with Dr. Weinberg as Director. I have participated in several of the center's projects related to the organization of science in the Soviet Union and to feasible approaches to digest the scientific literature. I consider these activities a natural follow-on to my duties in ONR, London.

I consider these activities a natural follow-on to my duties at ONRL.

Microwave Cerenkov Radiation from an Electron Beam

John R. Neighbours, Physical Sciences, 1980 - 1981

My first physics career consisted of about 25 years of work in solid-state physics and ultrasonics. Shortly before my tour of duty at ONRL, I, along with Fred Buskirk (also from the Naval Postgraduate School--NPS) became interested in free electron lasers (FEL).

While stationed in London, I covered principally solid-state physics, but I did manage to attend the FEL conference at the Majorana School in Erice, Sicily. This meeting and subsequent visits in Europe resulted in an ONRL report on FEL work in Europe.

I did manage to attend the FEL conference at the Majorana School in Erice, Sicily.

After I returned to NPS, Buskirk and I tried some experiments at stimulating a Cerenkov laser, using the electron beam from the NPS 100 MeV Linac. During the course of these experiments we became interested in the unexpectedly strong microwave radiation from the beam at angle substantially greater than the Cerenkov angle given by $\mathrm{Cos}\theta_c = 1/n\beta$. This was unexpected, since one would normally expect the intensity of radiation to increase with frequency so that the optical portion of the spectrum would be dominant. We developed a theory (Buskirk and Neighbours, 1983) in which bunches of electrons in a beam could radiate coherently at frequencies determined by the spacing between the bunches, and consequently overcome the large disparity ($\sim 10^4$) between optical and microwave regimes. In addition to an increase in intensity as a result of coherent radiation, there is diffraction associated with the finite path length of the electron beam. This effect causes the principal Cerenkov radiation peak to be broadened and shifted to larger angles as well as introducing many subsidiary radiation maxima. Both the theory and experiments (Neighbours et al., 1984 and Maruyama et al., in press) show that substantial power can be radiated at MHz to GHz frequencies depending on the spacing and structure of the electron beam. The radiation arises from the oscillations in polarization of the medium which are set into motion by the time-dependent fields produced by the passing charged particle beam.

A periodic beam composed of many similar charge bunches will have associated periodic fields which will produce radiation at the fundamental beam frequency as well as harmonics. (The fundamental beam frequency is determined by the spacing of the individual charge bunches.) A beam composed of a single charge bunch has a continuous radiated energy spectrum. However, the radiated power from a periodic charged particle beam and the radiated energy per unit frequency from a single bunch beam have the same angular distribution.

The results of our calculations and experiments have resulted in a number of published results. We have also looked at the possible effects of charge distribution (Maruyama et al., 1985) within an electron bunch upon the

radiation patterns, so that our analysis of the space and frequency domain is fully complete.

Recently we have made calculations (Buskirk and Neighbours, 1985) of the development of fields from an electron beam as a function of time. The analysis for finite length beam (Buskirk and Neighbours, in press) will be published soon.

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Bone Tissue Characterization: A London/Jerusalem/Los Angeles Connection

Moses A. Greenfield, Biological Sciences, 1980 - 1982

It was a very cold, rainy and overcast London in early January 1980 when I arrived to take up the duties of a liaison scientist at the Office of Naval Research Branch Office, London. The bad weather dissipated soon enough, but, more importantly, there were gracious welcomes from Captain Phillip Gibber and then acting Chief Scientist Fred Saalfeld, himself newly arrived from the Naval Research Laboratory.

I saw my "mission" in simple terms. I planned to visit the university laboratories and medical schools in Europe and Israel where exciting work in my field, Medical Physics, was ongoing, and to report these matters in the *European Scientific Notes*, as it was called in those days. It turned out to be not quite that simple. I discovered soon enough that very often my "card of admission" was to give a lecture in my particular area of research--characterization of bone tissue.

The Jerusalem Connection. One of the best visits I had was at the Hebrew University in Jerusalem, with Professor Arye Weinreb of the Racah Institute of Physics. Weinreb is not only a distinguished scientist in the field of molecular physics, but he is also a leading medical physicist in Israel. One of the medical research areas that he works in is the measurement of trabecular bone mineral density, an important aid in the early diagnosis of osteoporosis. (Osteoporosis is an aging process or a disease that afflicts millions of postmenopausal women.) About 2 years later, early 1982, Weinreb wrote me to ask whether I could arrange a postdoctoral fellowship in my Bone Laboratory at the University of California, Los Angeles (UCLA) for one of his new

One of the best visits I had was at Hebrew University in Jerusalem, with Professor Arye Weinreb of the Racah Institute of Physics.

Ph.D.'s, Isaac Leichter. Dr. Leichter had a $10,000 grant from Israel, not really enough in high-priced Los Angeles; fortunately I was able to supplement his grant with one from the UCLA School of Medicine.

An indication of the productivity and quality of Leichter's contributions is the fact that he is coauthor on six papers published in refereed journals (first name twice). To top that, Leichter won the annual prize of the Crump Institute for Biomedical-Engineering, an arm of UCLA's School of Engineering. It was for his personal contributions while working in our Bone Laboratory.

This fruitful interaction between Weinreb and myself, and with Leichter, is a direct outgrowth of my work as a liaison scientist.

This fruitful interaction is a direct outgrowth of my work as a liaison scientist.

The UCLA Laboratory Work. Prior to my visit with Weinreb the work in the UCLA Bone Laboratory had emphasized measurements with cortical bone, the hard and tough bone tissue which supports the skeleton (femur, vertebral column, etc.). However, Weinreb and other investigators had turned their attention to measurements of the density of trabecular bone mineral. This is the softer, lacy structure (trabeculae) found at the growing ends of the long bones. Since the rate of remodeling of trabecular bone is about eight times greater than that of cortical bone (Snyder et al., 1975), changes in bone mineral density due to osteoporosis are first expected in trabecular bone.

The method that we have developed at UCLA measures the true trabecular bone mineral density (TBMD), and is relatively insensitive to the presence of overlying cortical bone, or of the presence of bone marrow. The method follows a suggestion by Puumalainen and coworkers (1976) in Finland, and depends on the measurement of the ratio of coherent to Compton-scattered photons from the heel (trabecular bone of the calcaneus). The photons arise from the irradiation of the heel by gamma rays from the long-lived radioisotope americium-241. The calcaneus is chosen as the site for examination because of its accessibility (subcutaneous on three sides), and because it is largely composed of trabecular bone. Also, it has been shown by Chalmers (1973) and Evans et al. (1984) that the rate of loss of mineral in the calcaneus is similar to the rate of loss in the vertebral body.

The apparatus (Shukla et al., 1986) used for measuring TBMD consists of a source holder in which is located about 1.2 Curies (44.4-GBq) americium-241, with a principal gamma emission of 60 keV photons, and a high-purity germanium detector (22 mm^2, 7 mm thick), with a scatter angle of 71°. (See Figure 1.) We determined that the combined effect of both the photon energy and the scatter angle on the sensitivity is best described by a single parameter, the momentum transfer (Leichter et al., 1984). An experimental and quasi-theoretical examination of this parameter led to a choice of a scatter angle of 71°. To limit the measurement to trabecular bone without including any cortical bone or surrounding soft tissue, a defined sampling volume

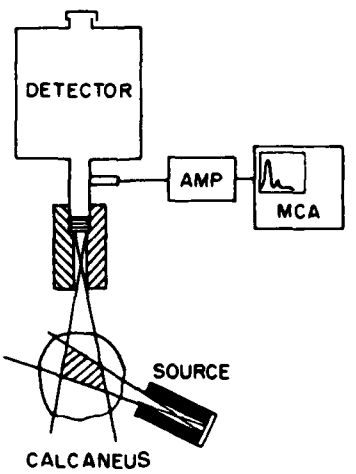

Figure 1. Apparatus used for the coherent to Comton scattered photon ratio method of measuring bone mineral density.

is necessary. This is achieved by using collimators for the source and detector, and the intersection of the views of these collimators constitutes the sampling volume (shaded area in Figure 1.). The sampling volume in this experimental arrangement is approximately 5 ml. Since the sampling volume is only 5 ml, one can be assured that it lies entirely within the trabecular bone only. The examination of each heel takes about 10 minutes to acquire a statistically adequate number of counts (standard deviation ~2 percent). The absorbed soft tissue dose in each heel is 2000 μGy (200 mrad), comparable to the absorbed dose in a conventional x-ray of the foot. We have obtained an absolute accuracy to within 5 percent in cadaver calcanei, and a reproducibility to within 4 to 5 percent for *in vivo* subjects (Shukla et al., 1985).

We have obtained an absolute accuracy to within 5 percent in cadaver calcanei, and a reproducibility to within 4 to 5 percent for *in vivo* subjects.

The results obtained to date include values for: (1) normal males and normal females (defined as healthy volunteers who are not suffering from any condition known to affect bone density), (2) a small group of osteoporotic females, and (3) a small group of patients with paraplegia secondary to spinal trauma.

Normal Subjects. To date measurements have been made on 109 normal subjects including 56 females (ages 18-73) and 53 males (ages 22-77). The mean TBMD value for males was 260 mg/cc with a standard deviation (SD) of 38 mg/cc. The mean TBMD value for females was 247 mg/cc with a SD of 33 mg/cc. Both heels were measured for all the subjects, and the mean percentage difference was 7.9 for males and 7.3 for females.

Ambulatory Osteoporotics. This group included females diagnosed as osteoporotics on the basis of spinal radiographs. The TBMD has been measured for 12 osteoporotics, and a mean TBMD of 205 mg/cc was obtained with a SD of 35 mg/cc. The mean percentage difference between the right-left heels was 17.

Paraplegics. The TBMD measurements have been made on 19 paraplegics including 12 males and 7 females. A mean TBMD of 156 mg/cc was obtained with a SD of 36 mg/cc. The mean percentage difference between the right-left heels was 12.

Discussion of the UCLA Bone Work. There is a relatively large difference in the mean TBMD values for the paraplegic group as compared to the normal female group. Although the difference for the osteoporotic group (compared to normal females) is smaller, this difference is nevertheless statistically significant at a level of $p < 0.001$. Although the statistics are presently small, the right-left differential, when combined with the TBMD value, may ultimately prove to be a useful parameter for the prediction of bone mineral loss.

The right-left differential, when combined with the TBMDA value, may ultimately prove to be a useful parameter for the prediction of bone mineral loss.

At present our normal female group consists of mainly perimenopausal to postmenopausal women. We expect to expand this data base to include adult females of different age groups ranging from 18 to 80 years, so that a normal data base can be generated for each decade of age.

Since the measurement method is accurate to within 5 percent, the most useful employment of this technique may be to follow individuals serially as a function of time, both to assist in the diagnosis of osteoporosis, and to check effectiveness of therapeutic strategies.

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ONRL: A Naval Officer's Perspective

CDR Joseph A. Strada, Director Naval Applications Division, 1980 - 1984

My 4-year tour of duty at ONR London, as the Aerospace Systems Officer and Director of the Naval Applications Division, was somewhat of an anomaly for a naval officer, yet a unique opportunity for professional growth.

For the naval officer, the ONRL experience is a distinctly different one from that of his colleague, the liaison scientist. The naval officer finds himself immersed in a technical, yet quasi-diplomatic, culture in which he represents the US Navy. This stimulating climate provides valuable experience for future assignments--especially those in Washington, DC where most military alumni of ONRL find themselves sooner or later.

The Naval Officer finds himself immersed in a technical, yet quasi-diplomatic, culture in which he represents the US Navy.

The quasi-diplomatic experiences were, for me, the most enjoyable, and they have served me well in my present tour of duty. My most memorable experiences in this regard include: attending a formal Trafalgar Night Dining In, at the invitation of the Royal Navy, in the lovely Painted Hall at Greenwich Royal Naval College; representing the American Ambassador at the commissioning of a new unit of the Royal Navy Association on the 4th of July; representing the US Navy at the funeral service for Sir John Martin, inventor of the famed Martin-Baker ejection seats, which have saved the lives of so many naval aviators. Such unique events were themselves set in an environment of regularly occurring functions (e.g., monthly meetings of the British-American Forces Dining Club); these too provided ideal opportunities to cultivate fruitful relationships with officers of allied military forces.

In my current assignment as Deputy Program Manager for the Joint Tactical Information Distribution System (JTIDS), I frequently deal with former colleagues in the British, German, Italian, French, and Norwegian Ministries of Defense. I can do so with confidence because I have had insight into their organizations, their unique military objectives and requirements, and, to some extent, their cultures.

The technical setting for the ONRL naval officer is the exhibition hall (the air show, the exposition, the demonstration) and NATO. Here he encounters Europe's technologists from industry and government. Unlike the liaison scientist, his focus is upon the naval applications of emerging

technologies. He must rely on his operational experience, within his proven warfare specialty, coupled with his technical education, to assess operational utility to the US Navy. The technology spectra--aerospace, surface, and subsurface systems--are vast, forcing the successful Naval Applications Division officer to broaden his knowledge base and expand his network of naval contacts both at home and in Europe.

His focus is upon the naval applications of emerging technologies.

Here again, the dividend is a large one, especially for future tours in the Navy's acquisition and development commands. Any major acquisition program embraces a variety of technologies, and the successful Program Manager must have a working familiarity with all of those appropriate to his program. Furthermore, many program aspects which might appear peripheral in Washington (e.g., international standardization, technology transfer, interoperability) occupy center stage in NATO.

In reflecting from a Washington perspective upon my assignment to ONR London, I find that it significantly expanded my technology base, heightened my awareness of allied naval requirements, left me with a tantalizing taste of international military protocol, and improved my preparation for the challenges of Navy program management.

Summary of M Activities as a Liaison Scientist

Kenneth D. Challenger, Materials Science, 1984 - 1986

This report was one of the last pieces Dr. Challenger wrote while still on staff at ONRL. He completed his tour in May of this year.

I have been the Liaison Scientist for Materials Science for ONR London for the past 2 years. I came to Europe with good contacts in my own specialities (fatigue, fracture, high-temperature mechanical behavior, and welding). However, it quickly became apparent that the European developments in materials science in which the US has most to gain were outside my specialties (except welding). The most exciting new developments in materials science are occurring in the development of advanced materials, ceramics, and composites. Consequently, I spent a significant part of my time reviewing and assessing subjects which only 2 years ago I knew very little about. It has taken some time to build up contacts and my own confidence in these fields.

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Activities and Output. The duties of a liaison scientist can be divided into several categories: (1) liaison travel, (2) conference attendance, (3) organizing trips for participants in the Visiting Scientist Program--VSP, (4) organizing workshops or conferences to be supported by ONRL, (5) documentation for the *European Science Notes*, *Science Newsbriefs*, and ONRL reports, and (6) other.

Travel. To do his job properly, a liaison scientist must spend a large fraction of his time traveling. In the past 2 years, I have spent about 220 days out of the office attending conferences, making liaison visits, and traveling to and from these conferences and visits. Taking into account annual leave, holidays, and weekends, this represented about 50 percent of my working time. I visited about 80 different establishments in 17 different countries; only 20 percent of this travel was in the UK; the rest was spent in Eastern and Western Europe and the Middle East. The trips in the UK were generally very short and scheduled to fit in

between longer trips outside the UK. One consequence of this is that I have not covered the research activities in the UK nearly as well as my predecessor. However, one can convincingly argue that it was not necessary to completely cover the activities in the UK because they had been quite thoroughly covered in the previous few years.

My trips outside the UK averaged about 10 to 11 days each. If attending a conference, I usually arranged a few liaison visits at establishments close to the site of the conference. About 65 of the 220 travel days were spent attending 12 different conferences (two of which were partially sponsored by ONRL). I attended many more conferences during my first 6 months in Europe than after that time. This was done intentionally to acquire contacts for future liaison visits. Now, at the end of my 2 years, I have so many new contacts that I could very effectively spend another year following them up. Data for these follow-ups will be left in a file for my successor.

Now at the end of my 2 years, I have so many new contacts that I could very effectively spend another year following them up.

I had to spend a considerable amount of time planning each trip for the 80 visits. The US Defense Attache Office (USDAO) in the embassy of each country visited must be given an itinerary at least 30 days before the trip. The name, address, and telephone number of the principal contact and the date of each visit must be firm by this time. For my trips to Eastern Europe (Poland, Hungary, and Czechozlovakia) it required about 6 months to make the arrangements and obtain approvals. The point that I want to make is that a liaison scientist must be very organized and plan his travel a few months in advance. Some visits can be arranged in a few minutes by a telephone call; others require several letters before a firm date can be set. I have found that if everything is carefully documented in writing one has no problems with last-minute changes or cancellations. I did not have a single visit cancelled in my 2 years. I am now a firm believer in the telex system; all Europeans have access to a terminal and it is the accepted method of communication in Europe. I normally send a telex to my contact the week before my trip just to remind him of the time and date of my visit.

Unfortunately, the liaison scientist must make all his own travel arrangements (except booking of flights). This can also involve many telephone calls, letters, and telex's. I estimate that I spend 12 to 16 hours planning each liaison trip.

Another activity while traveling is writing. I found it necessary to at least write a draft of most of my *ESN* articles while on the road; otherwise I could not keep up. I normally chose train over air travel within Europe as I found it more conducive to writing.

I found it necessary to at least write a draft of most of my ESN articles while on the road: otherwise I could not keep up.

I found that there are two busy travel periods and two slack travel periods each year. I used the slack periods to plan and arrange my travel for most of the busy periods and to work on VSP and conference/workshop activities. My busy travel periods have been from September through the middle of December, and March through the middle of July. The weather is so unpredictable and unfriendly in January and February that travel is very difficult, and all of Europe is on holiday during the end of July and all of August. This means that the 100 or so working days per year on travel are crammed into an 8- or 9-month period.

Conference and Workshop Support. One of the more recent programs at ONRL, initiated during James Daniel's tenure just shortly before I arrived, was to divert most of the conference-support funding into support of workshops or special sessions at conferences which directly address the needs of ONR and the US Navy. These require much more effort on the part of the liaison scientist, but in my experience

they are worth the effort. I organized only one workshop during my 2 years. I discussed various topics with Navy personnel before selecting the damage tolerance of fiber-reinforced composites as the theme for the workshop. This topic must have been a good choice because five DoD scientists from the US participated in the workshop--one from the Air Force, three from the Navy (NRL, NADC, ONRHQ), and one from the Army. The workshop included representations from the UK (most well represented), France, West Germany, Australia, and, of course, the US. The travel expenses of the non-US participants were covered by ONRL, but the US participants came at the expense of their own organizations.

I have had many favorable comments from the participants on the value and success of the workshop. In my opinion one of the better aspects of the workshop was that I selected people representing all facets of the subject; i.e., materials science, structural mechanics, testing, design, repair, and fabrication. They enjoyed the opportunity to hear each others' views of the major problem areas and to work together planning the approaches to solve these problems.

Reports. As I sit here writing again I am forced to stop and think about how much time I have spent writing in the past 2 years. I know it is fair to say that I have put more words to paper as a liaison scientist than on any other job I have had. I am more efficient with my writing time now than I was 2 years ago, but writing still occupies a large fraction of my time. My best guess is that it takes me 1 to 2 days to assemble my thoughts and write one *ESN* article and another 4 hours in proofreading and incorporating the comments by the three reviewers (editor, scientific director, and one peer). My goal has been to write two *ESN* articles per month; thus, about 3 or 4 days per month are spent in writing *ESN* articles. This, however, is not the only writing requirement; conference reports, workshop reports (weeks were spent on one alone), assessment reports, and letters also occupy a considerable amount of time.

I know it is fair to say that I have put more words to paper as a liaison scientist than on any other job I have had.

Like traveling, writing is a mandatory part of the job. I have written 42 articles for *ESN*; eight *News and Notes* articles; 12 *Science Newsbriefs*; one article for the ONR Far East publication, *Scientific Bulletin*, one conference report; one workshop summary report; two assessment reports; one journal article on the workshop results; and a summary report.

Visiting Scientist Program. The ONRL program that, in my opinion, most successfully helps to promote collaboration between US and European scientists is our VSP. Both this program and the workshop/conference program are highly productive investments of both ONRL funding and the liaison scientist's time. I have arranged trips for 16 VSP's; five from the UK, three from Israel, two from West Germany, two from France, one from the Netherlands, two from Austria, and one from Sweden. The feedback from the Navy laboratories on this program has been excellent.

Other Activities. *Visiting Faculty at the Naval Postgraduate School (NPS)* This activity is perhaps unique to me because of my association with NPS. I have tried to use my contacts as a liaison scientist to help the materials science program at NPS by encouraging a few people to join NPS as visiting faculty. I have been successful in two cases; Dr. D.V. Edmonds, University of Oxford, has spent 15 months as a visiting faculty member and Professor A. Rosen, Technion, will spend June through September 1986 at NPS.

Direct Assistance to Navy Laboratories We are occasionally called upon by the Navy laboratories to help find unique facilities and to assist them in using these facilities in Europe. I have worked very closely with Dr. B.B.

Rath at NRL on a variety of topics. The most noteworthy is with Leeds University. During a conference in Europe, Rath became aware of a unique microscope--a photo emission electron microscope--owned by Leeds University. He asked me to investigate the possibility for NRL scientists to use the instrument for a series of experiments studying the mechanisms of phase transformations in some Ti alloys. I made three trips to Leeds to visit Dr. C. Hammond to discuss the microscope and perform some preliminary demonstration experiments. Hammond agreed to work with a NRL scientist for up to 3 or 4 weeks free of cost in the hope that the experiments would be successful and that a collaborative research program could be established. The demonstration experiments were successful, and Dr. Imam Ashraf from NRL came to Leeds University for 3 weeks and completed his experiments with the help of the Leeds University personnel. Hammond has recently visited NRL as a participant of the ONRL Visiting Scientist Program in order to plan a long-term collaborative program.

Buddy Contacts During my tenure at ONRL I have developed several "buddies" at naval laboratories and ONR with whom I communicate frequently. I give them a quick report on hot items and request their input into my activities.

I give them a quick report on hot items and request their input into my activities.

In addition to these contacts "at home," most ONRL scientists interact with their counterparts in the European Office of Aerospace Research and Development (EOARD) and the US Army Research, Development, and Standardization Group (USARDSG). My counterparts, Drs. F. Oertal and I. Ahmad, USARDSG and Lt.Col. J. Hansen and Maj. L. Smith, EOARD, and I have frequent conversations exchanging contacts and ideas. In fact, when the question of funding European research arises during a liaison visit, I always explain that ONRL does not support research in Europe, but ONRHQ might if there is very strong justification; for those individuals where this very strong justification does not exist (only once in my 2 years did I feel that I should encourage a proposal), I will sometimes refer and recommend them to my Army or Air Force counterparts.

Summary and Comments. Hopefully I have made it clear that life as a liaison scientist is active and varied. I have not experienced a dull moment, and most aspects of the job are fantastic. I would not exchange the past 2 years' experience for any other 2 years of my working life to date. I was given some guidance as to what countries to emphasize, but I was never told where I should or should not travel.

One aspect of the job that I found very enjoyable was working with intelligent people from many diverse fields. So often we surround ourselves with people who share our own interests. These 2 years have been a pleasant change.

I want to end this little personal exposition with a quote from Dr. Samuel Johnson that summarizes my present state of mind. "When a man tires of London--he is tired of life." I am not ready to come home.

The ONRL Staff

We have used all our resources to make the lists which follow as complete as possible. Should there have been a record missing from the source material for the functions listed, there will be, of course, a missing name.

The lists do not include the naval personnel who have served in ONRL's Naval Applications Division. The records available to us for members of this division were too incomplete to yield a reasonably full listing. Therefore, and with much regret, we elected to forego including one, recognizing, at the same time, the high value of the contribution the members of that division--collectively and individually--have made and are making still to the fulfillment of ONRL's mission.

Commanding Officers

Robert E. Robinson, Jr. COMO, USN	1946-1947	William A. Hopkins CAPT, USN	1969-1970
James P. Clay CAPT, USN	1947-1950	Andrew J. Van Tuyl, Jr. CAPT, USN	1970-1972
Philip D. Lohmann CAPT, USN	1950-1953	Russell C. Drew CAPT, USN	1972-1973
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Bradley F. Bennett CAPT, USN	1957-1960	Philip F. Gibber CAPT, USN	1978-1981
John K. Sloatman, Jr. CAPT, USN	1960-1964	Lewis B. Sykes CAPT, USN	1981-1983
William W. Schaefer CAPT, USN	1964-1966	Marshall A. Howard CAPT, USN	1983-1986
Clarence T. Froscher CAPT, USN	1966-1969	Terry J. McCloskey CAPT, USN	1986-Present
Dick W. Thurston (Acting) CDR, USN	1969-1969		

Chief Scientists / Scientific Directors

Holbrook M. MacNeille	1946-1947	Alfred B. Focke	1968-1970
Daniel B. Clapp	1948-1948	Edward I. Salkovitz	1970-1972
Charles E. Sunderlin	1949-1951	Victor J. Linnenbom	1972-1974
Maurice E. Bell	1951-1953	James H. Schulman	1974-1977
Samuel R. Aspinall	1953-1956	Herbert Solomon	1978-1979
Gerard F.W. Mulders	1956-1957	Fred E. Saalfeld	1980-1980
David M. Gates	1957-1957	William J. Condell, Jr.	1980-1981
Howard E. Page	1957-1959	Phillip A. Clarkin (Acting)	1981-1981
Immanuel Estermann	1959-1964	Francis A. Richards	1981-1983
Peter King	1964-1966	James W. Daniel	1983-1985
Aubrey W. Pryce	1966-1968	David L. Venezky	1985-Present

Scientific Staff

Behavioral Sciences

Henry A. Imus	1951-1952	Newell H. Berry CDR, MSC, USN	1968-1969
Clarence H. Graham	1952-1953		
William D. Neff	1953-1954	Joseph Zeidner	1968-1969
Lee J. Cronbach	1955-1956	Ivan N. Mensh	1969-1970
Frank A. Geldard	1956-1957	James T. Lester, Jr.	1972-1974
D. Farnsworth CDR, MSC, USN	1958-1959	James M. Miller	1975-1977
		Jack A. Adams	1977-1978
John E. Rasmussen CAPT, MSC, USN	1964-1967	Nicholas A. Bond	1981-1983
		Richard E. Snow	1983-1985
John A. Nagay	1965-1966	William D. Crano	1986-Present
H. Wallace Sinaiko	1967-1968		

Biological Sciences

Daniel H. Moore	1949-1951
George H. Smelser	1951-1952
John L. Nickerson	1952-1953
T.K. Ruebush CAPT, MC, USN	1953-1955
John O. Hutchens	1954-1955
Herman I. Chinn	1955-1957
O. Schneider CAPT, MC, USN	1955-1957
D.E. Goldman LCDR, MSC, USN	1956-1957
J.A. English CAPT, DC, USN	1956-1958
Harve J. Carlson	1956-1958
J.A. O'Donoghue CAPT, MC, USN	1958-1959
Zareh Hadidian	1958-1960
W.E. Ludwich CAPT, DC, USN	1958-1960
Abraham M. Shanes	1958-1960
J.H. Stover, Jr. CAPT, MC, USN	1959-1962
Augustus T. Miller	1960-1961
Jackson W. Foster	1961-1962
E.A. Walsh CAPT, DC, USN	1961-1964
J.R. Kingston CAPT, MC, USN	1962-1964
S.W. Handford CAPT, MSC, USN	1963-1964
C.E. Meyers CAPT, DC, USN	1965-1966
Clarence N. Peiss	1965-1966
Mitchell Weissbluth	1967-1968
Leonard M. Libber	1967-1969
George A. Hottle	1970-1971
Ralph R. Sonnenschein	1971-1972
Arthur W. Frisch	1972-1974
Martin Blank	1974-1975
John B. Bateman	1975-1978
Thomas C. Rozzell	1983-1985
Claire E. Neurath	1984-Present

Earth Sciences

George Z. Dimitroff	1955-1956
Robert E. Holzer	1959-1960
Morton L. Barad	1967-1968
Harley J. Walker	1968-1969
Roy E. Hanson	1969-1971
Seymour L. Hess	1971-1972
Robert J. Dolan	1974-1975
Leslie G. Meredith	1975-1976
Albert I. Barcilon	1975-1977
Robert J. Dolan	1983-1984

Material Sciences

Bernard D. Cullity	1948-1952
George J. Szasz	1948-1955
Amos J. Shaler	1950-1951
Samuel R. Aspinall	1950-1953
Edward Epremian	1951-1954
John C. Sheehan	1953-1954
John B. Fenn	1954-1955
Lawrence Himmel	1954-1956
Ralph Roberts	1955-1956
Benjamin P. Dailey	1956-1957
John W. Irvine	1957-1958
Oleg D. Sherby	1957-1958
Alvin S. Gordon	1957-1958
Hans B. Jonassen	1958-1959
Johannes Weertman	1958-1959
Calvin L. Stevens	1959-1960
Edward R. Tompkins	1960-1961
James H. Schulman	1960-1961
Ralph R. Nash	1960-1961
George J. Janz	1961-1962
David S. Lieberman	1961-1963
Mortimer J. Kamlet	1962-1963
Walter Beck	1963-1965
Ronald E. Kagarise	1963-1964
Cyrus Klingsberg	1963-1964
Bodo Bartocha	1964-1966
S. Young Tyree	1964-1966
William S. Pellini	1965-1966
Jerome B. Cohen	1966-1967
James A. Bierlein	1966-1967
Ralph A. Burton	1967-1969
Harry A. Lipsitt	1967-1969
Lawrence M. Slifkin	1969-1970
Charles P. Smyth	1969-1970
John G. Foss	1970-1972
Lambert Tall	1971-1972
David M. Mason	1972-1973
Ivan B. Cutler	1972-1973
Irvin Wolock	1973-1974
Benson R. Sundheim	1974-1975
Herbert Herman	1975-1976
Abraham Sosin	1976-1977
I. Melvin Bernstein	1977-1978
Jeff Perkins	1978-1979
Philip A. Clarkin	1981-1982
Ronald W. Armstrong	1982-1983
Kenneth D. Challenger	1984-1986
Louis Cartz	1986-Present
Robert W. Vest	1986-Present

Mathematical and Engineering Sciences

Sherman C. Lowell	1949-1951	Robert H. Owens	1970-1971
F. Joachim Weyl	1951-1952	Arthur A. Ranger	1971-1972
Wallace D. Hayes	1952-1954	Franklin F. Kuo	1971-1972
Charles V. Smith	1954-1956	Bernard H. Carson	1972-1973
Alan J. Hoffman	1956-1957	David F. Dyer	1972-1973
Julian D. Cole	1956-1957	Bruce J. McDonald	1973-1974
Paul R. Garabedian	1957-1958	Harold G. Elrod	1974-1975
Marshall P. Tulin	1957-1959	Waldo G. Magnuson, Jr.	1974-1975
Thomas L. Saaty	1958-1959	Robert H. Nunn	1975-1977
Leo Katz	1959-1960	William J. Gordon	1976-1978
George Herrman	1960-1961	Martin Lessen	1976-1979
Harold Levine	1960-1962	C. Joseph Martin	1977-1978
Anatol Roshko	1961-1962	Irving Kaufman	1978-1979
Thomas F. Ogilvie	1962-1963	Robert E. Machol	1979-1980
Matthew P. Gaffney	1962-1964	Philip Fire	1980-1981
Gilles M. Corcos	1964-1965	Y.S. Wu	1980-1982
Bernard Epstein	1964-1966	Ronald R. Barr	1982-1983
Harry Williams	1966-1967	Max N. Yoder	1982-1983
Frederick H. Todd	1967-1968	Charles J. Holland	1984-1985
Ivar Stakgold	1967-1969	Patrick Leehey	1984-1985
Philip Mandel	1969-1970	Eugene F. Brown	1985-Present
William E. Jahsman	1969-1970	Daniel J. Collins	1986-Present
Richard D. Mathieu	1970-1971		

Ocean Sciences

Robert S. Dietz	1954-1958	Norris W. Rakestraw	1965-1966
Vernon M. Albers	1956-1957	John D. Costlow	1966-1968
Robert W. Hiatt	1957-1958	Winfield J. Trott	1966-1967
Marston C. Sargent	1958-1960	James E. Hanks	1969-1970
Murray Strasberg	1959-1960	John M. Leonard	1972-1973
Warren Thompson	1960-1961	Fred N. Spiess	1974-1975
Herman Medwin	1961-1962	J. Paul Walsh	1975-1976
Eugene C. Haderlie	1962-1963	Wayne V. Burt	1979-1980
Adrian F. Richards	1962-1964	J. Thomas Warfield	1985-1986
L. Eugene Cronin	1964-1965	Jerome Williams	1985-Present

Physical Sciences

Albert M. Stone	1946-1948	George C. Sponsler	1956-1958
Edward J. Schremp	1946-1948	Daniel J. Zaffarano	1957-1958
Donald J. Montgomery	1947-1948	Robert T. Webber	1957-1960
Roger C. Lyndon	1946-1948	Nelson M. Blachman	1958-1960
Samuel D. Cornell	1946-1948	David Z. Robinson	1959-1960
Kenneth R. Eldredge	1946-1953	Josef M. Jauch	1959-1960
Thomas Coor, Jr.	1948-1950	William S. Ament	1959-1960
Paul M. Marcus	1948-1950	Leopold B. Felsen	1960-1961
Maurice E. Bell	1948-1951	Lawrence J. Laslett	1960-1961
Gordon F. Hull	1949-1950	Hubert Heffner	1960-1961
Peter W. Forsbergh	1949-1950	Albert N. Guthrie	1961-1961
Walter L. Hyde	1950-1953	Diogenes Angelakos	1961-1962
S. Fred Singer	1950-1953	Henry A. Sandmeier	1961-1963
John R. Reitz	1952-1954	Jules R. DeLaunay	1962-1963
Warren N. Arnquist	1953-1955	Carl E. Menneken	1962-1963
Arthur Roberts	1953-1955	Glenn H. Keitel	1963-1964
John R. Richardson	1953-1957	Nathan Seeman	1963-1965
Hollard B. Huntington	1954-1955	Edward L. Murphy	1963-1966
Henry R. Alexander	1954-1955	Donald Ross	1964-1965
James S. Smart	1955-1957	Eugene P. Cooper	1964-1965
David M. Gates	1955-1957	James G. Brennan	1965-1966

Physical Sciences (Cont'd)

Elliot H. Weinberg	1965-1966	David K. Cheng	1975-1976
Bernard O. Seraphin	1965-1967	Thomas A. Kitchens, Jr.	1975-1976
Maurice W. Long	1966-1967	Nelson M. Blachman	1976-1977
Paul Maycock	1966-1967	Aubrey W. Pryce	1976-1979
Alfredo Baños	1970-1971	Clifford C. Klick	1977-1979
Richard W. Bell	1967-1969	Robert W. Rostron	1977-1979
Walter K. Kahn	1967-1968	Vern N. Smiley	1977-1979
John E. Scott	1967-1968	Willard D. Bascom	1978-1980
Edward F. Carome	1968-1969	Richard S. Hughes	1979-1979
Henry M. Foley	1968-1969	Irwin M. Freundlich	1979-1979
H. John Shaw	1968-1969	Moses A. Greenfield	1979-1980
Howard Chang	1969-1970	Theodore C. Cheston	1979-1981
Robert A. Hein	1970-1971	John R. Neighbours	1980-1981
Richard O. Rowlands	1970-1971	A. Paul Schaap	1980-1981
Alfredo Baños	1970-1971	Vivian T. Stannett	1982-1983
William J. Condell, Jr.	1971-1972	David Mosher	1982-1984
Edgar A. Edelsack	1972-1973	Robert L. Carovillano	1982-1984
Arthur H. Waynick	1972-1974	Chester M. McKinney	1983-1984
Robert J. Collins	1973-1974	David L. Venezky	1984-1985
Roy F. Potter	1974-1975	Norman F. Ness	1984-1985
Richard T. Schneider	1975-1976	Paul Roman	1984-Present
Larry G. DeShazer	1975-1976		

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